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# SUMMARY:
# NORTHEAST REGION BENCHMARK PROGRAM
# RESULTS 1992-1997

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March 1999

Prepared for: Alberta Environmental Protection/ Alberta Agriculture, Food, and Rural Development

Contract 98RDD31

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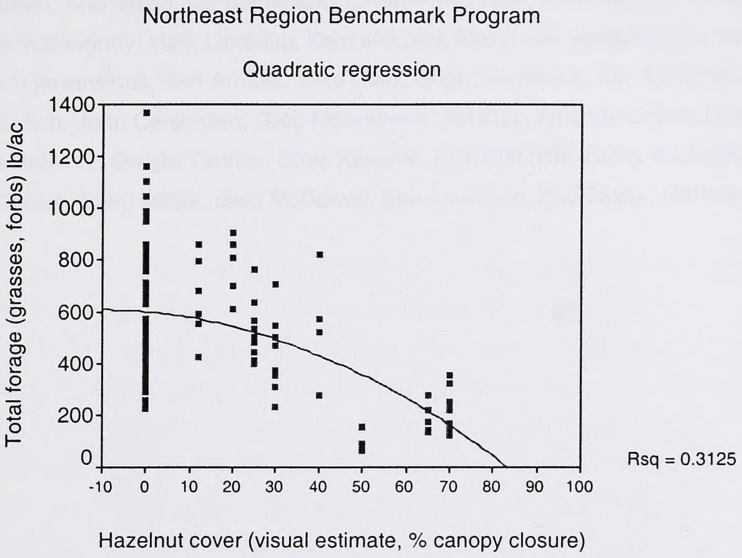
ERRATA: Northeast Benchmark Program Summary Document

- Figure 6 was not included with the original document. It should be inserted immediately following page 31.

Figure 6. Effect of hazelnut cover on grass/forb productivity



- The header for Table 12 and the references section should read "Northeast Benchmark", not "Eastern Slopes Benchmark".

- On page 20, the sentence near the bottom of the text begins "This is particularly evident for the Aspen/Rose-blueberry type, possibly because a high proportion of twig and leaf biomass is derived from blueberry and tall bilberry…". The reference to tall bilberry is incorrect; it should be dwarf bilberry (Vaccinium caespitosum).

## ACKNOWLEDGEMENTS

The author gratefully acknowledges the involvement of 46 people without whom completion of both benchmark programs would have been impossible: Gerry Ehlert, Darren Labonte, Ed Karpuk, Jeanne deValois, Al Benner, Elly Marshall, Clarence Mackowecki, Ken Dutchak, Marilyn Rayner, Troy Berreth, Arlo Stade, Ian Sutherland, Chester Jedrzycki, Keith Ainsley, Chuck Richardson, Mike Willoughby, Mark Lindberg, Kerri McLoed, Allan Hare, Jim Lindquist, Stu MacKay, Dennis Holowaychuk, Bert Arthurs, Mike Clark, Brian Kremeniuk, Kim Stromme, Frank Gazdag, Keith Stretch, John Carscallen, Greg McAndrews, Bill Kuly, Amanda Bogen, Lorna Hommy, Luanne Berjiane, Dwight Tannas, Dave Karasek, Felix Gebbink, Cathy Erickson, Peggy Meunier, Beth Cornish, Marg Meijer, Glen McDowall, Bob Anderson, Rod Taylor, Marlene Krueckl and Julie Laux.

# 1 INTRODUCTION

This document presents the results of the 1992-1997 Northeast Region Benchmark Program established by Alberta Agriculture, Food, and Rural Development (Public Lands Division) to quantify native range productivity in forested areas of the Northeast Boreal Region[1]. This program and the closely related 1993-1998 Eastern Slopes Benchmark Program in west-central Alberta, were both established to collect basic ecological data on native rangelands, with the goal of developing range management plans within an ecologically sound framework. The intent of both benchmark programs was to obtain forage and browse productivity data on relatively undisturbed, native, deciduous forested rangeland, which is one of the most extensive native rangeland types in both east-central and west-central Alberta.

Both benchmark programs were designed and implemented with reference to documents that described the program goals, research questions, working hypotheses, data collection methods, data analysis directions, and data presentation models. The *Terms of Reference: Northeast Region Benchmark Program Version 4* (Ehlert and Downing 1992) is the publication that guided the Northeast Region Benchmark Program throughout its six-year span. The reader is referred to the *Terms of Reference* for a detailed description of experimental design considerations, including ecological and sampling theory and data collection criteria; excerpts from this publication are included within the current summary report.

This summary report is presented in three sections. The first outlines the purpose, objectives, and working hypotheses that defined the Northeast Region Benchmark Program. The second presents a brief overview of the program area, a summary of the data collection methods used, and a description of the approach taken to data analysis. The third provides a summary of range productivity data organised in several different ways, and involves a descriptive analysis of productivity for each vegetation type, a comparison of productivity data between vegetation types, and a comparison of productivity data between the Eastern Slopes and Northeast Region Benchmark program areas.

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[1] This region is an administrative region of Alberta Agriculture, Food, and Rural Development and Alberta Environmental Protection.

## 1.1 PURPOSE, OBJECTIVES, WORKING HYPOTHESES, AND SIGNIFICANT CHANGES

### 1.1.1 Purpose and objectives

The purpose of the Northeast Region Benchmark Program is to collect and deliver specific range management information for deciduous forest range ecosystems managed by Public Lands Division within the Lower Foothills Natural Subregion[2]. Deciduous forests represent the majority of current and potential livestock grazing on forested rangelands within the Northeast Region. The program was restricted to one natural subregion in order to minimize effects on forage productivity due to climatic variation. A detailed vegetation survey (Downing and Karpuk 1992) identified several deciduous ecosystem types defined by vegetation and site characteristics, three of which were chosen to address the following two questions:

> *(1) What is the net primary forage and browse productivity of ungrazed or lightly grazed deciduous forest-dominated vegetation types? and*
>
> *(2) Are there any significant differences in production between vegetation types?*
>
> (page 3, *Terms of Reference, Northeast Region Benchmark Program*)

### 1.1.2 Working hypotheses

The primary working hypotheses for the benchmark program are derived directly from these questions:

(1) The Aspen/Rose (Beaked hazelnut)/Forb/Reedgrass vegetation type has the same mean understory production (forbs, grasses) and forage species diversity as the Aspen/Beaked hazelnut-Rose/Wild sarsaparilla or Aspen/Rose-Blueberry types.

(2) The Aspen/Rose (Beaked hazelnut)/Forb/Reedgrass, Aspen/Beaked hazelnut-Rose/Wild sarsaparilla, and Aspen/Rose-Blueberry types all have the same net mean annual browse production.

(page 15, *Terms of Reference, Northeast Region Benchmark Program*)

During the course of the study, two other working hypotheses were developed:

(3) Forb and grass productivity is not affected by shrub cover and shrub type.

(4) There is no difference between the Dry Boreal Mixedwood and Lower Foothills natural subregions in terms of overall deciduous range productivity.

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[2] Natural subregions are broad areas of similar climate as expressed by vegetation, and provide a logical means of presenting regional patterns of more or less similar ecological potential (Alberta Environmental Protection 1994).

The third working hypothesis was developed following analysis of the Northeast Region Benchmark data (Downing and Karpuk 1992), where it appeared that forb and grass productivity may be strongly influenced by heavy shrub cover, particularly hazelnut (*Corylus cornuta*). The fourth working hypothesis was suggested by comparisons of tabular and graphical information between the Northeast Region and Eastern Slopes Region Benchmark Programs.

### 1.1.3 Significant changes

During the course of this study, there were two significant changes to classification schemes employed within the Province. Adoption of a single unified regional classification by Alberta Environmental Protection in 1994 resulted in regional name changes and some changes to region boundaries. However, all of the benchmark plots originally established in the Low Boreal Mixedwood Ecoregion were included within the climatically similar Dry Boreal Mixedwood Natural Subregion.

In 1996, plot data for the Boreal Forest Natural Region, including plots belonging to the Northeast Region Benchmark Program, were analysed and a forest classification system involving ecosites, ecosite phases and community types was formally defined by the Department of Environmental Protection in the document *Field Guide to Ecosites of Northern Alberta* (Beckingham and Archibald 1996). This analysis produced community types very similar to those described by Downing and Karpuk (1992). The 1992 community types and 1996 ecosites compare as follows:

| **1992 vegetation type (Downing and Karpuk)** | **1996 ecosite (Beckingham and Archibald)** |
|---|---|
| Aspen/Rose-blueberry | Ecosite phase b2:blueberry Aw(Bw); community type b2.1 Aw(Bw)/blueberry-bearberry |
| Aspen/Rose (Beaked hazelnut)/Forb/Reedgrass | Ecosite phase d1:(low-bush cranberry Aw); community type d1.6 (Aw/rose) |
| Aspen/Beaked hazelnut-Rose/Wild sarsaparilla | Ecosite phase d1:(low-bush cranberry Aw); community type d1.3 (Aw/beaked hazelnut) |

# 2 STUDY AREA DESCRIPTION AND METHODS

## *2.1 Study area description*

A detailed description of the program area is given in the *Terms of Reference* and in *Aspen Vegetation Types of the Low Boreal Mixedwood Ecoregion, East Central Alberta* (Downing and Karpuk 1992). The program area includes that part of the Dry Boreal Mixedwood Natural Subregion to the north and east of Edmonton; this region and the location of benchmark plots within it is shown in Figure 1. It includes an area of approximately 24000 km$^2$, extending from Townships 53 to 66 inclusive and including all areas within the Dry Boreal Mixedwood Subregion east of Range 19 W4M to the Saskatchewan border. Major communities within the study area include Smoky Lake, St. Paul, Lac la Biche, Elk Point, and Cold Lake. Most of the area is accessible by all weather roads; oil lease roads provide access to some of the more remote sites. Benchmark plot establishment was restricted to Crown lands that were forested by deciduous-dominated stands.

The Dry Boreal Mixedwood Natural Subregion is characterised primarily by a continental climatic regime, generally demonstrating large seasonal and diurnal temperature variations, cold winters and short cool summers. The Dry Boreal Mixedwood Natural Subregion is essentially equivalent to the Low Boreal Mixedwood Ecoregion described by Strong and Leggat (1992).

Deciduous vegetation on public lands within the program area was classified into five major types by Downing and Karpuk (1992). The vegetation type name in the list below indicates the dominant, diagnostic species in the tree, shrub, forb and/or grass layers:

(1) Aspen/Rose(beaked hazelnut)/Forb/Reedgrass vegetation type – moderately well to imperfectly drained, moist to very moist luvisols on slightly stony fine textured till.

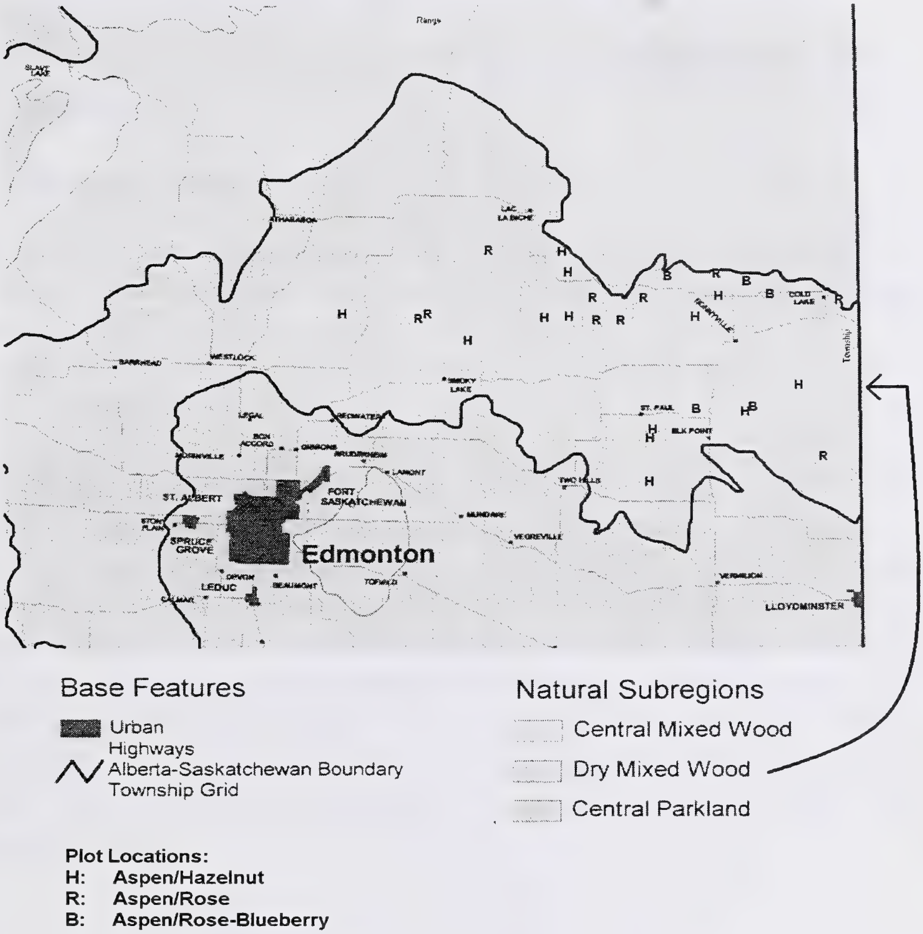
(2) Aspen/Rose-Blueberry vegetation type – Well-drained, dry acidic luvisols, brunisols on coarse-textured glaciofluvial or till materials.

(3) Aspen/Beaked hazelnut-Rose/Wild Sarsaparilla vegetation type – Moderately well drained, moderately moist luvisols on fine textured tills.

(4) Aspen/ Beaked hazelnut-Rose/Wild peavine vegetation type – Moderately well drained, moderately moist luvisols on fine textured tills in the southern half of the Lower Boreal Mixedwood ecoregion.

(5) Aspen/Rose-lowbush cranberry vegetation type - developed on moderately-to well-drained moderately moist luvisolic soils on fine to moderately fine textured till, along the Dry Boreal Mixedwood-Central Mixedwood boundary.

Figure 1. Northeast Region Benchmark Program Area


Range
SLAVE LAKE
ATHABASCA
LAC LA BICHE
COLD LAKE
BONNYVILLE
Township
BARRHEAD
WESTLOCK
SMOKY LAKE
ST. PAUL
ELK POINT
LEGAL
REDWATER
BON ACCORD
GIBBONS
BRUDERHEIM
MORINVILLE
LAMONT
ST. ALBERT
FORT SASKATCHEWAN
STONY PLAIN
SPRUCE GROVE
Edmonton
MUNDARE
VEGREVILLE
TWO HILLS
DEVON
LEDUC
BEAUMONT
TOFIELD
CALMAR
VERMILION
LLOYDMINSTER
H
R
B
Base Features
Urban
Highways
Alberta-Saskatchewan Boundary
Township Grid
Natural Subregions
Central Mixed Wood
Dry Mixed Wood
Central Parkland
Plot Locations:
H: Aspen/Hazelnut
R: Aspen/Rose
B: Aspen/Rose-Blueberry

A subset of plots belonging to three of these vegetation types were chosen for benchmark sampling:

- the Aspen/Rose(beaked hazelnut)/Forb/Reedgrass vegetation type (abbreviated "**Aspen/Rose**" in this report);
- the Aspen/Rose-Blueberry vegetation type (abbreviated "**Aspen/Rose-Blueberry**"); and
- the Aspen/Beaked hazelnut-Rose/Wild Sarsaparilla vegetation type (abbreviated "**Aspen/Hazelnut**") .

### 2.2 Data Collection Methods

Data collection methods are fully detailed in Section 3.2 of the *Terms of Reference*. The intent of data collection was to provide a statistically valid sample of deciduous forest range communities in good to excellent condition, and to control sources of experimental variation due to measurement as much as possible. The 'sampling unit', or basic unit of measurement on the ground, is the benchmark site.

Statistically valid (unbiased) sampling requires the random selection of benchmark sites from a population of potential sites. The 1992 report on deciduous vegetation types of the Northeast Region by Downing and Karpuk identified a total potential plot population of 75 sites, which was subsequently expanded to 77 sites to include the Aspen/Rose-blueberry type. This population was sufficient to randomly select a subset of 5 to 10 plots in each of three vegetation types. Table 1 lists the plots selected for each vegetation type and the year in which they were established. Plots belonging to the Aspen/Rose type were established in 1992 and sampled for six years, plots belonging to the Aspen/Hazelnut type were established in 1993 and sampled for five years, and plots belonging to the Aspen/Rose-blueberry type were established in 1994 and sampled for four years.

**Table 1a. Benchmark sites by vegetation type and date of establishment**

| Vegetation Type | Plots |
|---|---|
| Aspen/Rose , established 1992 | NEBM016, NEBM023, NEBM033, NEBM048, NEBM052, NEBM054, NEBM064, NEBM065, NEBM067, NEBM069 |
| Aspen/Hazelnut, established 1993 | NEBM010, NEBM019, NEBM025, NEBM026, NEBM038, NEBM039, NEBM044, NEBM058, NEBM060, NEBM072 |
| Aspen/Rose-Blueberry, established 1994 | NEBM014, NEBM032,NEBM051,NEBM076, NEBM077 |

Control of experimental variation through control of measurement criteria was achieved in the following manner:

1. To reduce experimental variation due to resampling the same transects in successive years (effects of previous year clipping on regrowth), plot design limited resampling a given transect to once every five years.
2. To reduce variation due to cattle grazing, all sites in the Northeast Region program were fenced. A fence maintenance program was carried out throughout the six-year program period.
3. Transects were clearly and permanently marked with tagged steel posts. Circular sampling frames of standard dimension ($0.5m^2$) were used for forb and grass/graminoid sampling; marked circular $5m^2$ plots were used for shrub-leaf and shrub-twig biomass collection.
4. To reduce variation due to seasonal differences in vegetation development, all sampling was carried out between July 1 and July 31. Shrub-twig sampling was conducted immediately following leaf-off, usually in the last week of September or the first week of October.
5. Staff familiar with the area and with sampling methods undertook the data collection; the same crew collected data for four years in the Northeast Region Benchmark program area.
6. All samples were collected and oven-dried in paper bags of standard weight, and were weighed immediately following drying to reduce variations due to forage moisture content.
7. Standard data collection forms were used throughout the program period.
8. Land reservations were established on selected benchmark sites to limit the possibility of disturbance.

## 2.3 Data conditioning and stratification

Keypunched data were passed through analysis programs written to detect and correct a variety of problems, including invalid species, plot identification, layer, cover, and transect codes. Each species was assigned to one of three forage quality classes – good, fair, or poor[3] – according to a list of species-quality associations provided by Ehlert (1991, pers. comm.) (Appendix 1). Each species was also assigned to one of four layers – forb, grass/graminoid, shrub-leaf (leafy shrub biomass), and shrub-twig (current annual twig growth) – depending on the species growth form and the transect it occurred in. Litter was assigned to a fifth layer and was assigned a forage quality of “poor”.

A set of data management routines were used to compile data into four different formats according to species, quality, and layer codes, as follows:

- Biomass values totalled by forage quality and layer for each plot and each year in each vegetation type
- Biomass values totalled by forage quality for each plot and each year in each vegetation type.
- Biomass values totalled by layer for each plot and each year in each vegetation type.
- Biomass values totalled by species, layer, and forage quality for each plot and each year in each vegetation type.

These datasets provide insights at various levels of aggregation for each vegetation type, and were used during each year of the program to generate interim analysis reports for review by Public Lands staff. These datasets form the basis for analysis in this summary report, as well. Appendix 5 includes printouts of SAS® programs used to produce tables and graphs.

Tests for normality[4] indicated that raw forage weight values followed a normal distribution. However, a cube root transformation was applied to the data. This was done to be consistent with the closely related Eastern Slopes Benchmark Program, where a cube root transformation was required to create a dataset approximating the normal distribution more closely. Specifically, the hypothesis test of similarities between the Northeast and Eastern Slopes regions requires that both datasets be compared on an equivalent basis. The results of Kolmogorov-Smirnov normality tests on untransformed and cube-root transformed data are provided in Appendix 2 and

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[3] “Good” quality forage species are those that are highly palatable and that grow tall enough to readily be grazed by cattle; they are likely to decrease in abundance under grazing pressure. “Fair” quality forage species are those which are readily grazed or browsed but are not as palatable; these may decrease or increase under grazing pressure. “Poor” quality forage species are those that are either marginally palatable and/or that grow too close to the ground to provide much usable forage; these species often increase under grazing pressure.

[4] Certain inferential statistical techniques, such as analysis of variance, assume that distributions are normal. If this assumption is violated, other methods, usually referred to as ‘non-parametric’ methods, should be used or the data should be transformed so that its distribution more closely approaches the normal distribution.. Several statistics can be used to determine whether sample data are normally distributed, including the ratio of skewness and kurtosis to their respective standard errors, graphical methods such as normal probability plots, and statistical methods such as the Kolmogorov-Smirnov tests (SPSS 1998).

demonstrate that, for the Northeast Region, the transformation provides neither significantly better nor worse normal approximations than the raw data does.

### *2.4 Data analysis methods*

Data analysis involves the production of standard descriptive statistics and the development of inferences based on parametric or non-parametric comparisons. Descriptive statistics include the mean and median, standard deviation, standard error of the mean, minimum and maximum values, and range about the mean at a specified confidence interval. Graphical presentations are also useful to clarify statistical trends.

Analysis of variance (ANOVA) is generally the most useful and powerful inferential method for testing the hypotheses presented above. It is essentially a test of whether two or more sample means (biomass values) could have been obtained from populations with the same parametric mean for biomass (Sokal and Rohlf 1969). Its basic assumption is that the data are derived from a normally distributed population. The cube-root transformation applied to biomass data as discussed above and in Appendix 2 provides a reasonably good approximation of normality. Further discussions of this method are provided in the results section.

Linear regression analysis was applied to address hypothesis 3 concerning the differences in forb and grass/graminoid forage productivity between sites as a function of tall shrub cover, for each of the three vegetation types. Both the significance of the test (i.e. the probability that the results attained would be expected if there were no relationship between forage and shrub cover) and the strength of the test (how much of the variation in forage productivity can be attributed to shrub cover) are important.

Data analysis software included SPSS® and SAS®. SPSS was used to produce most of the summary statistics in this document; SAS was used to produce most of the graphs and tables which are on file with the Resource Data Division, Alberta Environmental Protection.

# 3 RESULTS

Results are presented below in five sections. The first section presents a summary of descriptive statistics for individual species and forage groups within each of the three vegetation types. The second section provides a summary of descriptive statistics for individual species and forage groups within each of four ecosite/community types. The third section provides a summary of reliability assessments for individual species and forage groups. The fourth section presents the results of four hypothesis tests concerning the relationship between grass and forb productivity and vegetation type, browse productivity and vegetation type, species diversity and vegetation type, and grass and forb productivity and shrub cover. The fifth section provides a discussion of hypothesis tests concerning forage productivity differences between vegetation types in the Northeast Region Program area and between the Eastern Slopes and Northeast program areas.

## *3.1 Descriptive statistics: Summary of biomass characteristics by species or forage groups*

### 3.1.1 Forage group summaries

Table 2 presents statistics for total dry weight productivity averaged across all plots within each vegetation type by year and across all years. In this table, all forage types (good, fair, poor, shrub, grass/grasslike, and forb) are combined. The total average productivity range between all three vegetation types is about 200lb/ac. Substantial productivity variations can however occur within vegetation types, depending on the plot and year sampled; this is indicated by the wide span between maximum (the maximum value observed for any given year in one plot) and minimum. Figure 2 shows average dry weight productivity (square symbol) along with the minimum and maximum values observed for any plot in any year within the vegetation type.

Table 3a presents statistics for total dry weight productivity averaged across all plots within each vegetation type by year and across all years for forage quality classes and forage layers. The 'good' and 'fair' forage quality classes have been combined for each forage layer under the assumption that both classes will contribute equally to usable forage. Table 3b presents statistics for total dry weight productivity averaged across all plots within each vegetation type by year and across all years for forage layers only. The Aspen/Rose and Aspen/Rose-blueberry types evidently have comparable forb and grass productivity; the Aspen/hazelnut type appears to have higher shrub productivity and lower forb and grass productivity than the other two types.

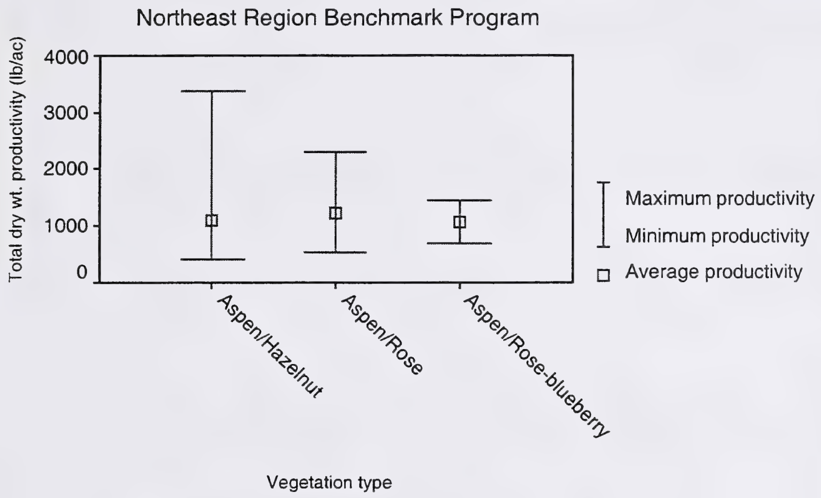
A visual comparison of good and fair forage productivity for various forage types (Figure 3) shows parallel trends in productivity by forage type. The Aspen-Rose and Aspen/Rose-blueberry types have higher forb and grass productivity than the Aspen/Hazelnut type; the Aspen/Hazelnut type

has higher browse productivity. Table 4 presents a summary of the more commonly occurring species by layer and forage quality; the Aspen-Alder type is likely more productive for poor quality forage partly because of high alder leaf biomass. Detailed summary graphs of productivity information organized by forage quality type, layer, and vegetation type and detailed summary tables for each vegetation type and forage quality/layer combination by year and for all years are on file with Alberta Environmental Protection, Resource Data Division.

**Table 2. Total forage productivity statistics, all forage types combined**
**Northeast Region Benchmark Program**

| | | | | Total lb/ac (all forage types) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Mean | Maximum | Minimum | Standard Error of Mean |
| Vegetation type | Aspen/Hazelnut | YEAR | 1993 | **1350.52** | **3361.23** | **550.72** | **270.33** |
| | | | 1994 | **1074.79** | **2075.68** | **621.90** | **148.80** |
| | | | 1995 | **969.30** | **1529.07** | **526.46** | **103.75** |
| | | | 1996 | **1124.01** | **1528.89** | **643.49** | **96.12** |
| | | | 1997 | **996.61** | **1456.10** | **403.90** | **108.05** |
| | | Summary: all years | | **1103.05** | **3361.23** | **403.90** | **70.96** |
| | Aspen/Rose | YEAR | 1992 | **1049.63** | **1641.46** | **647.41** | **120.70** |
| | | | 1993 | **1269.76** | **2283.52** | **549.29** | **163.96** |
| | | | 1994 | **1393.05** | **2069.26** | **714.67** | **158.61** |
| | | | 1995 | **1203.11** | **1783.64** | **623.33** | **138.51** |
| | | | 1996 | **1099.82** | **1797.92** | **711.28** | **113.80** |
| | | | 1997 | **1340.07** | **1994.16** | **764.62** | **133.78** |
| | | Summary: all years | | **1225.91** | **2283.52** | **549.29** | **56.75** |
| | Aspen/Rose-blueberry | YEAR | 1994 | **871.95** | **1120.00** | **685.41** | **87.68** |
| | | | 1995 | **1031.08** | **1447.18** | **799.95** | **116.31** |
| | | | 1996 | **1145.86** | **1405.26** | **875.23** | **98.02** |
| | | | 1997 | **1191.60** | **1260.57** | **1034.36** | **41.25** |
| | | Summary: all years | | **1060.12** | **1447.18** | **685.41** | **50.13** |

Figure 2. Maximum, minimum, and average total dry weight productivity



All forage types combined; all years combined

### Table 3a. Total forage productivity statistics by forage layer and quality
### Northeast Region Benchmark Program

| | | | Lbs/acre forage | | | |
|---|---|---|---|---|---|---|
| Vegetation type | Forage Layer | Forage Quality | Mean | Minimum | Maximum | Standard Error of Mean |
| Aspen/Hazelnut | Forb | Good and fair | 139.05 | 27.12 | 363.22 | 12.36 |
| | | Poor | 204.56 | 20.52 | 467.41 | 16.93 |
| | Grasses/grasslike | Good and fair | 49.72 | 1.07 | 165.20 | 6.25 |
| | Shrub-Leaf | Good and fair | 483.47 | 54.95 | 1849.83 | 44.21 |
| | | Poor | 29.47 | .54 | 193.74 | 5.19 |
| | Shrub-Twig | Good and fair | 135.01 | 14.45 | 477.04 | 15.75 |
| | | Poor | 10.19 | .00 | 155.03 | 3.27 |
| | Litter | Poor | 51.57 | .00 | 198.92 | 6.25 |
| Aspen/Rose | Forb | Good and fair | 263.85 | 65.12 | 908.41 | 22.46 |
| | | Poor | 223.95 | 73.32 | 464.73 | 10.39 |
| | Grasses/grasslike | Good and fair | 105.13 | .89 | 526.10 | 14.60 |
| | Shrub-Leaf | Good and fair | 287.18 | 33.00 | 959.79 | 24.43 |
| | | Poor | 90.15 | .00 | 788.53 | 17.49 |
| | Shrub-Twig | Good and fair | 110.07 | 18.55 | 383.92 | 10.02 |
| | | Poor | 35.12 | .00 | 370.72 | 9.23 |
| | Litter | Poor | 110.45 | .18 | 396.40 | 13.50 |
| Aspen/Rose-blueberry | Forb | Good and fair | 185.16 | 71.00 | 375.89 | 15.67 |
| | | Poor | 381.29 | 200.70 | 635.28 | 26.68 |
| | Grasses/grasslike | Good and fair | 202.55 | 121.31 | 290.79 | 11.35 |
| | Shrub-Leaf | Good and fair | 92.15 | 6.60 | 169.12 | 12.23 |
| | | Poor | 62.04 | .00 | 293.11 | 17.31 |
| | Shrub-Twig | Good and fair | 39.27 | 6.78 | 134.69 | 7.35 |
| | | Poor | 19.30 | .00 | 76.53 | 5.26 |
| | Litter | Poor | 78.37 | .00 | 140.58 | 9.06 |

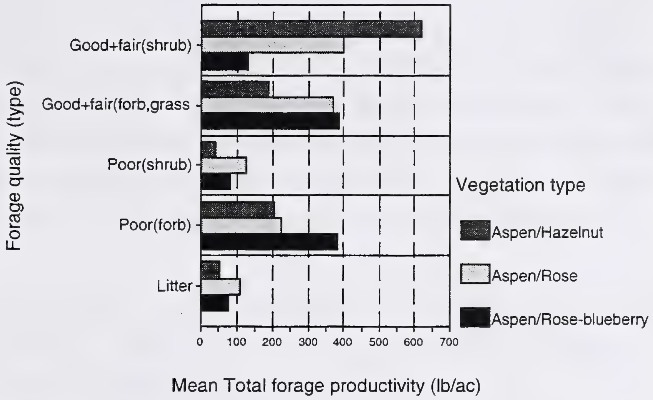
### Table 3b. Total forage productivity statistics by forage layer only Northeast Region Benchmark Program

| | | Total forage (lb/ac) | | | |
|---|---|---|---|---|---|
| Vegetation type | Forage Layer | Mean | Minimum | Maximum | Standard Error of Mean |
| Aspen/Hazelnut | Forb | **343.61** | **62.98** | **786.92** | **27.88** |
| | Grasses/grasslike | **49.72** | **1.07** | **165.20** | **6.25** |
| | Shrub-Leaf | **512.94** | **89.74** | **2043.57** | **46.24** |
| | Shrub-Twig | **145.20** | **26.22** | **479.00** | **16.27** |
| | Litter | **51.57** | **.00** | **198.92** | **6.25** |
| Aspen/Rose | Forb | **487.81** | **186.07** | **1296.79** | **27.78** |
| | Grasses/grasslike | **105.13** | **.89** | **526.10** | **14.60** |
| | Shrub-Leaf | **377.33** | **60.83** | **1206.88** | **30.31** |
| | Shrub-Twig | **145.19** | **33.18** | **458.67** | **13.03** |
| | Litter | **110.45** | **.18** | **396.40** | **13.50** |
| Aspen/Rose-blueberry | Forb | **566.45** | **277.95** | **1011.17** | **38.72** |
| | Grasses/grasslike | **202.55** | **121.31** | **290.79** | **11.35** |
| | Shrub-Leaf | **154.19** | **10.35** | **437.08** | **22.44** |
| | Shrub-Twig | **58.57** | **16.41** | **136.48** | **7.25** |
| | Litter | 78.37 | .00 | 140.58 | 9.06 |

Figure 3. Average productivity, forage quality and type

Northeast Region Benchmark Program

All years included



### 3.1.2 Species summaries.

A total of 136 different vascular species were recorded over the six-year sampling period for this program. However, 28 species averaging over 10lb/ac (ll.3kg/ha) in one or more of the vegetation types were the main contributors to biomass productivity. Table 4 summarises average dry weight productivity for these main contributors across all years by vegetation type and forage class. Figures 4a through 4c show the average dry weight productivity of species belonging to good or fair forage quality classes in all three vegetation types.

From Table 4 and figures 4a through 4c, it is apparent that species contributing most to good and fair quality forage productivity are somewhat variable between the three types. Higher marsh reed grass (*Calamagrostis canadensis*), vetch (*Vicia americana*) and fireweed (*Epilobium angustifolium*) biomass are associated with the Aspen/Rose type, possibly because higher light levels and/or better moisture supplies encourage more prolific growth of these species. High ricegrass (*Oryzopsis asperifolia*) and hairy wild rye (*Elymus innovatus*) biomass is associated with the Aspen/Rose-blueberry type; possibly these species have a competitive advantage or better drought tolerance on the drier sites typical of this type. As might be expected, the Aspen/hazelnut type is associated with higher productivity of hazelnut (*Corylus cornuta*) than the other two types. Wild red raspberry (*Rubus idaeus*) and trembling aspen (*Populus tremuloides*) evidently contribute more to total biomass in the Aspen/hazelnut and Aspen/Rose types compared to the Aspen/Rose-blueberry type, probably because of better moisture and nutrient

conditions in the former two types. Cream-colored vetchling (*Lathyrus ochroleucus*), and rose (*Rosa acicularis, R. woodsii*) are major contributors to total biomass in all three types.

The abundance of other species is indicative of the relative moisture and nutrient status differences among the three sites. Bearberry (*Arctostaphylos uva-ursi*), twinflower (*Linnaea borealis*), dwarf bilberry (*Vaccinium caespitosum*), and blueberry (*Vaccinium myrtilloides*) occur with highest biomass in the Aspen/Rose-blueberry type and are typically associated with dry sites (e.g. the blueberry-Aw ecosite phase described by Beckingham and Archibald (1996)). Wild sarsaparilla (*Aralia nudicaulis*), dewberry (*Rubus pubescens*) and bracted honeysuckle (*Lonicera involucrata*) are typically associated with the moister Aspen/Rose and Aspen/Hazelnut sites.

More detailed summary graphs and summary statistics in tabular form for all species occurring in each vegetation type summarised over all years and for each year of the program are on file with Alberta Environmental Protection, Resource Data Division.

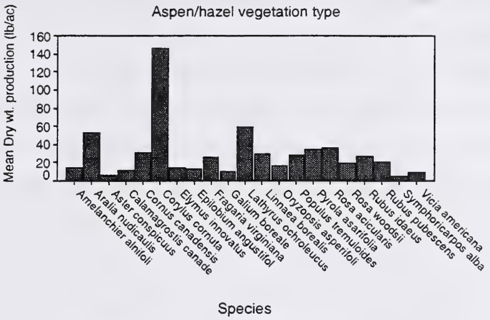
Table 4. Summary: Mean and standard error of the mean, dry weight productivity of major species, Northeast Region Benchmark Program

| | | | Vegetation type | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Aspen/Hazelnut | | Aspen/Rose | | Aspen/Rose-blueberry | |
| | | | Dry wt. production (lb/ac) | | Dry wt. production (lb/ac) | | Dry wt. production (lb/ac) | |
| Forage quality | Forage layer | Species | Mean | Standard Error of Mean | Mean | Standard Error of Mean | Mean | Standard Error of Mean |
| Good | Forb | Aster conspicuus | 6.0 | 1.9 | 3.3 | 1.3 | .0 | .0 |
| | | Lathyrus ochroleucus | 59.0 | 8.1 | 76.4 | 5.7 | 91.9 | 9.8 |
| | | Lathyrus venosus | .8 | .8 | 11.5 | 5.0 | .0 | .0 |
| | | Vicia americana | 8.5 | 1.8 | 29.3 | 4.2 | 13.2 | 2.3 |
| | Grasses/grasslike | Oryzopsis asperifolia | 16.6 | 3.0 | 3.2 | .9 | 102.9 | 13.5 |
| | Shrub-Leaf | Amelanchier alnifolia | 20.8 | 6.6 | 16.7 | 4.3 | 13.0 | 7.1 |
| | | Populus tremuloides | 44.7 | 20.2 | 46.6 | 9.4 | 7.5 | 4.3 |
| | Shrub-Twig | Amelanchier alnifolia | 6.4 | 2.0 | 5.0 | 1.3 | 1.3 | .8 |
| | | Populus tremuloides | 12.7 | 5.6 | 15.0 | 3.3 | 1.1 | .9 |
| Fair | Forb | Epilobium angustifolium | 12.5 | 3.2 | 75.6 | 16.9 | .1 | .0 |
| | | Galium boreale | 10.5 | 1.2 | 18.5 | 2.1 | 20.5 | 3.6 |
| | Grasses/grasslike | Calamagrostis canadensis | 12.0 | 2.6 | 74.6 | 14.8 | 3.6 | 1.3 |
| | | Elymus innovatus | 14.2 | 2.6 | 19.3 | 2.9 | 55.1 | 5.7 |
| | | Schizachne purpurascens | 1.1 | .2 | 1.7 | .5 | 15.9 | 5.5 |
| | Shrub-Leaf | Corylus cornuta | 246.5 | 36.9 | 12.9 | 7.9 | .2 | .2 |
| | | Rosa acicularis | 54.7 | 12.0 | 60.0 | 9.5 | 43.5 | 8.4 |
| | | Rosa woodsii | 29.3 | 8.2 | 45.7 | 8.5 | 17.8 | 8.9 |
| | | Rubus idaeus | 32.3 | 13.5 | 53.6 | 12.1 | .0 | .0 |
| | Shrub-Twig | Corylus cornuta | 45.4 | 10.1 | 12.8 | 7.1 | .0 | .0 |
| | | Rosa acicularis | 17.3 | 3.4 | 24.9 | 3.8 | 19.2 | 5.7 |
| | | Rosa woodsii | 9.1 | 2.7 | 6.3 | 1.9 | 9.6 | 4.0 |
| | | Rubus idaeus | 22.1 | 8.1 | 22.1 | 4.5 | .2 | .2 |
| Poor | Forb | Aralia nudicaulis | 51.9 | 6.5 | 59.5 | 10.0 | .0 | .0 |
| | | Arctostaphylos uva-ursi | .8 | .7 | .0 | .0 | 97.7 | 39.3 |
| | | Cornus canadensis | 31.1 | 3.9 | 39.3 | 3.0 | 63.4 | 9.6 |
| | | Fragaria virginiana | 25.7 | 5.0 | 37.1 | 3.0 | 47.6 | 7.3 |
| | | Linnaea borealis | 28.9 | 5.7 | 22.0 | 3.9 | 83.7 | 11.6 |
| | | Pyrola asarifolia | 35.0 | 8.0 | 27.0 | 3.5 | 27.5 | 6.3 |
| | | Rubus pubescens | 20.9 | 2.4 | 26.1 | 2.8 | 11.8 | 3.1 |
| | | Vaccinium caespitosum | 1.4 | .6 | .4 | .2 | 24.7 | 5.5 |
| | Shrub-Leaf | Alnus crispa | 1.9 | 1.9 | 25.9 | 15.4 | .0 | .0 |
| | | Lonicera involucrata | 1.7 | .9 | 19.3 | 4.4 | 6.4 | 6.0 |
| | | Symphoricarpos alba | 8.7 | 1.9 | 23.0 | 5.0 | 11.1 | 4.5 |
| | | Vaccinium myrtilloides | .7 | .3 | .2 | .1 | 25.5 | 15.2 |
| | Shrub-Twig | Alnus crispa | .0 | .0 | 15.7 | 8.8 | .0 | .0 |
| | | Lonicera involucrata | 1.1 | .6 | 6.1 | 1.9 | 2.1 | 1.4 |
| | | Symphoricarpos alba | 2.4 | .7 | 4.7 | 1.1 | 2.5 | 1.6 |
| | | Vaccinium myrtilloides | .5 | .3 | .4 | .4 | 10.3 | 5.0 |

**This page is provided for the reader's convenience (notes etc).**

Figure 4a. Major contributors to good and fair forage productivity

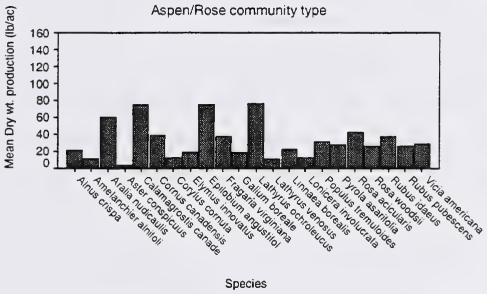
Northeast Region Benchmark Program



Some species labels truncated by graphing software

Figure 4b. Major contributors to good and fair forage productivity

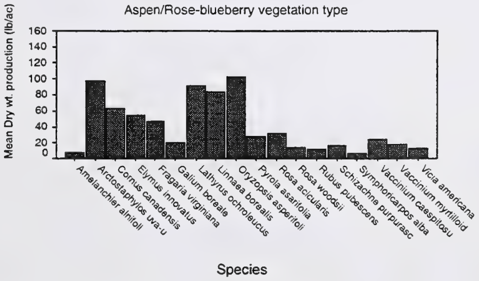
Northeast Region Benchmark Program



Some species labels truncated by graphing software

Figure 4c. Major contributors to good and fair forage productivity

Northeast Region Benchmark Program



Some species labels truncated by graphing software

### 3.2 Reliability assessments

According to the *Terms of Reference, Northeast Region Benchmark Program* (p. 32), the sampling intensity employed (number of plots per vegetation type) is considered adequate if biomass samples estimate the true population biomass within +/- 25 percent at least eight times out of ten (80 percent confidence). Detailed results of reliability assessments at confidence levels of 80 and 95 percent were conducted for forage quality, forage type (layer), combinations of forage quality and layer, and individual species occurring with greater than 5lb/ha average cover. Table 5 presents a summary of the assessments; detailed records are given in Appendix 4. When forage is grouped on the basis of relative quality or growth type, the reliability guidelines are satisfied. When quality and forage type are combined (not shown), most combinations meet the reliability criteria; however, biomass estimates for shrub-twig and shrub-leaf forage types split by forage quality are often outside the acceptable range. This is particularly evident for the Aspen/Rose-blueberry type, possibly because a high proportion of twig and leaf biomass is derived from blueberry and tall bilberry, both of which are difficult to sample because of their small sizes. Of the most common good and fair-quality species, only marsh reed grass meets the reliability criteria for all vegetation types, perhaps indicating a more even distribution within stands, on average, than other species such as cow parsnip or hairy wild rye. These results suggest that it is reasonable to assess forage production on the basis of broad forage classes, but risky to attach much importance to individual species quantities.

**Table 5. Summary of reliability assessment for forage types and major species.**

| Forage quality class | Meets/does not meet (+/-) | Comments |
|---|---|---|
| Good | + | Forage quality classes |
| Fair | + | |
| Poor | + | |
| Forage type | | |
| Shrub-leaf | + | |
| Shrub-twig | + | |
| Forb | + | |
| Grass | + | |
| Litter | + | |
| Major forage species (good and fair quality) | | |
| *Calamagrostis canadensis* | - | |
| *Elymus innovatus* | + | |
| *Oryzopsis asperifolia* | + | Insufficient to quantify for Aspen/Rose |
| *Lathyrus ochroleucus* | + | |
| *Vicia americana* | + | Outside acceptable range for Aspen/hazelnut |
| *Epilobium angustifolium* | - | |
| *Rosa woodsii* | - | |
| *Rosa acicularis* | - | |
| *Rubus idaeus* | - | |
| *Populus tremuloides* | - | |
| *Corylus cornuta* | - | Only within acceptable limits for leaf biomass, Aspen/Hazelnut type |

### 3.3 Comparison of forage productivity; Tests of Hypothesis 1 and 2

#### 3.3.1 Comparison of forage productivity between vegetation types within the Northeast Region Program Area

The preceding section indicated that there are quantitative and qualitative differences between vegetation types with respect to forage productivity. Figure 5 shows average total forage productivity (all forage layers and qualities combined) by vegetation type and year, and indicates an apparent productivity difference between vegetation types; moreover, there appear to be year-to-year productivity variations within vegetation types. This section examines the working hypothesis that there is no significant difference in forage productivity or species diversity between vegetation types. In light of the trends indicated in Figure 5, it is probably useful to examine the influence of vegetation type, year, and vegetation type and year acting together on forage productivity.

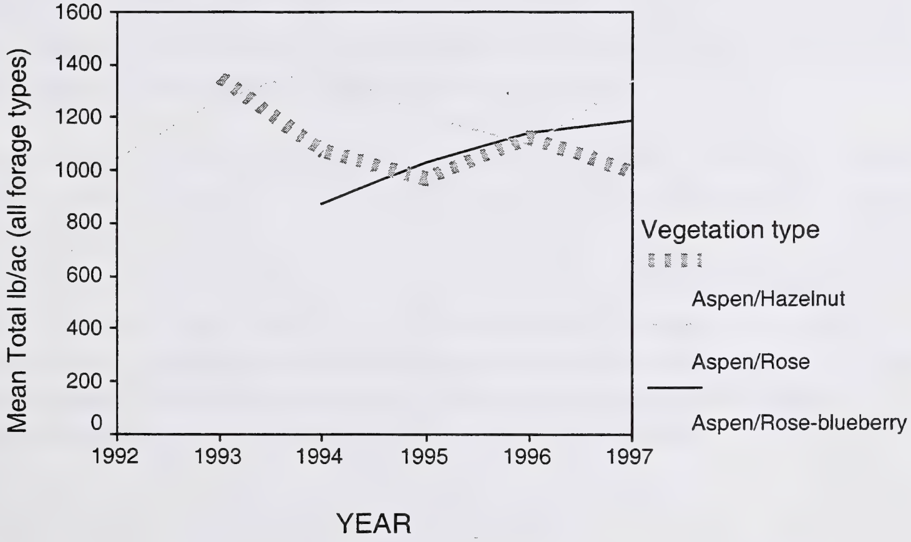


Figure 5. Yearly variations in total forage productivity

by vegetation type

Northeast Region Benchmark Program

#### 3.3.1.1 Statement of hypothesis

The working hypotheses being tested here are as follows:

(1a) The Aspen/Rose vegetation type has the same mean understory production (forbs, grasses) as the Aspen/Hazelnut or Aspen/Rose-Blueberry types.

(1b) The Aspen/Rose vegetation type has the same mean forage species diversity as the Aspen/Hazelnut or Aspen/Rose-Blueberry types.

(2) The Aspen/Rose, Aspen/Hazelnut, and Aspen/Rose-Blueberry types all have the same net mean annual browse production.

The first hypothesis stated above has two components, the first involving forb and grass productivity comparisons between vegetation types and the second involving species diversity comparisons. The second hypothesis involves only a comparison of browse productivity. Although neither hypothesis specifies that the sample population should be stratified by forage quality class, this aspect will be considered through post-hoc tests following the main hypothesis tests.

#### 3.3.1.2 Hypothesis test method: forage productivity (hypotheses 1a and 2).

Analysis of variance (ANOVA) is the statistical method applied to test these hypotheses. It is an appropriate method if several assumptions about the data are met – data should be normally distributed (i.e. approximate the shape of a normal curve), the groups being compared should have similar variances, and the data must have been collected in a random fashion. The cube-root transformation discussed above and the stratified random approach to sampling, where plots were selected at random, satisfactorily address these assumptions.

The ANOVA model applied here includes two main effects – vegetation type and year –and an interaction effect (vegetation* year)[5]. A valid comparison of the three vegetation types includes only those years in which data were collected on all three types (1994-1997). The assumption is that regional climatic factors will operate more or less similarly on each type throughout the Dry Boreal Mixedwood Natural Subregion in a given sampling year; although climatic variation between years is essentially unpredictable, these effects are equally applied to plots within each vegetation type. Both of the main effects can therefore be referred to as *fixed*, and the appropriate ANOVA procedure is referred to as a two-way Model I ANOVA.

### 3.3.1.3 Hypothesis test method: Species diversity, Hypothesis 1(b)

This test involves a comparison of the average number of vascular plant species that are associated with each vegetation type. There are, as mentioned above, a total of 136 vascular plant species (including shrubs) that were documented across all benchmark sites in the six years of the study. However, this hypothesis is directed toward answering the more general question of whether there are more species on average in one vegetation type than in others. A one-way ANOVA using the counts of forb and grass species actually clipped at each plot for each vegetation type between 1994 and 1997 was conducted to test this hypothesis.

### 3.3.1.4 Results of hypothesis tests

**Test 1(a): differences between vegetation types (forb and grass productivity)**

Table 6a summarises the results of ANOVA analysis for the forage productivity component of the first hypothesis test. The boldfaced line shows the overall effect of vegetation type on forage productivity. For grass and forb forage types combined, there is an overall significant difference in productivity between forage classes, as the overall F-statistic of 24.62 has a significance value of 0.000, well below the critical significance level of 0.05. The null hypothesis as stated is therefore rejected.

Table 6a also shows that there are no significant year-to-year variations; the calculated significance of 0.881 exceeds the critical value (p=0.05). There is also no significant interaction effect between vegetation type and year, which means that effects on forage productivity by vegetation type can be discussed without reference to year.

---

[5] A **main effect** in ANOVA is the effect of an individual factor (vegetation or year in this case). An **interaction effect** expresses the degree to which the variability in one of the main effects depends on the other. If the interaction effect in an ANOVA is significant, it means that variability in one of the main effects cannot be considered without reference to the other. For example, if interaction between vegetation type and year is significant, it means that productivity variations within vegetation type could not be discussed without reference to year.

**Table 6a. Analysis of variance, overall differences in forb and grass forage productivity between vegetation types, Northeast Region Benchmark Program**

Dependent Variable: Forb and grass productivity (lb/ac)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 82.782[a] | 11 | 7.526 | 4.923 | .000 |
| Intercept | 5827.009 | 1 | 5827.009 | 3811.550 | .000 |
| **Vegetation type** | **75.278** | **2** | **37.639** | **24.620** | **.000** |
| YEAR | 1.016 | 3 | .339 | .221 | .881 |
| Interaction between vegetation type and year | 4.704 | 6 | .784 | .513 | .797 |
| Error | 134.532 | 88 | 1.529 | | |
| Total | 6359.695 | 100 | | | |
| Corrected Total | 217.314 | 99 | | | |

[a] R Squared = .381 (Adjusted R Squared = .304)

If the overall F-statistic is significant, there are likely significant differences between at least two of the vegetation types. Table 6b demonstrates that there is a significant difference between all three of the vegetation types at the 0.05 probability level. The Aspen/Rose-blueberry type is significantly more productive on average than the Aspen/Rose type, which is in turn significantly more productive than the Aspen/Hazelnut type. The matter of statistical significance should be viewed in the broader context of its implications for management. Table 3b in Section 2 of this report indicates that the average difference between the most and least productive types for grasses and forbs (all quality classes combined) is on the order of 350 lb/ac.

**Table 6b. Multiple comparison test: Differences in forb and grass productivity between vegetation types, Northeast Region Benchmark Program**

Dependent Variable: Forb and grass productivity (lb/ac)
Bonferroni

| Vegetation type "I" | Vegetation type "J" | Difference betweeen mean of "I" and mean of "J" | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| Aspen/Hazelnut | Aspen/Rose | -1.3405* | .276 | .000 | -2.0153 | -.6658 |
| | Aspen/Rose-blueberry | -2.2383* | .339 | .000 | -3.0647 | -1.4118 |
| Aspen/Rose | Aspen/Hazelnut | 1.3405* | .276 | .000 | .6658 | 2.0153 |
| | Aspen/Rose-blueberry | -.8977* | .339 | .029 | -1.7241 | -7.1300E-02 |
| Aspen/Rose-blueberry | Aspen/Hazelnut | 2.2383* | .339 | .000 | 1.4118 | 3.0647 |
| | Aspen/Rose | .8977* | .339 | .029 | 7.130E-02 | 1.7241 |

Based on observed means.

*. The mean difference is significant at the .05 level.

### Test 1(b): differences in species diversity

There are statistically significant differences between vegetation types in terms of vascular species diversity. The overall ANOVA (not shown) is statistically significant (p=0.05), and a multiple comparison test (not shown) indicates that the Aspen/Hazelnut type has a significantly lower number of species than either of the other two types. The null hypothesis as stated is therefore rejected.

The actual species difference between the Aspen/Hazelnut type and the other two types is shown in Table 7. Although average vascular species diversity is statistically different, the difference is not great; there is a greater range of species counts between plots within each type than there is between types. Species diversity might be expected to be somewhat higher in the Aspen/Rose type than the Aspen/Hazelnut type because light levels are probably sufficient to allow a wider range of species to occur. The Aspen/Rose-blueberry type might be more diverse because sites belonging to this type have comparatively high microsite variability in terms of moisture regime. Small depressions in well-drained parent materials could provide strongly contrasting environments that support a different suite of plant species than the adjacent slightly higher areas.

**Table 7. Summary of vascular species count data by vegetation type, Northeast Region Benchmark Program**

| | | Mean | Minimum | Maximum |
|---|---|---|---|---|
| Total number of species occurring | Aspen/Hazelnut | 31 | 22 | 41 |
| | Aspen/Rose | 35 | 28 | 43 |
| | Aspen/Rose-blueberry | 35 | 21 | 48 |
| | Total | 34 | 21 | 48 |

### Test (2): Differences in browse productivity between vegetation types

The results of the ANOVA are shown in Table 8. There is a significant (P=0.05) difference between vegetation types in terms of average browse production across all years. The null hypothesis that total browse productivity is similar between the three vegetation types is not rejected.

Table 8 also shows that there are no significant year-to-year variations; the calculated significance of 0.08 exceeds the critical value (p=0.05). There is also no significant interaction effect between vegetation type and year, which means that effects on forage productivity by vegetation type can be discussed without reference to year.

If the overall F-statistic is significant, there are likely significant differences between at least two of the vegetation types. Table 8b demonstrates that there is a significant difference between two of three of the vegetation types at the 0.05 probability level. The Aspen/Rose-blueberry type is significantly less productive of browse on average than the Aspen/Rose and Aspen/Hazelnut types. These latter two types do not have significantly different browse productivity.

**Table 8. Analysis of variance: Overall differences beteween vegetation type and year for browse productivity, Northeast Region Benchmark Program**

| Dependent Variable | Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Cube root Browse productivity (lb/ac) | Corrected Model | 114.928[a] | 11 | 10.448 | 6.498 | .000 |
| | Intercept | 4870.236 | 1 | 4870.236 | 3029.194 | .000 |
| | **Vegetation type** | **95.376** | **2** | **47.688** | **29.661** | **.000** |
| | YEAR | 11.253 | 3 | 3.751 | 2.333 | .080 |
| | Interaction between vegetation type and year | 11.122 | 6 | 1.854 | 1.153 | .339 |
| | Error | 141.483 | 88 | 1.608 | | |
| | Total | 6150.365 | 100 | | | |
| | Corrected Total | 256.412 | 99 | | | |

a. R Squared = .448 (Adjusted R Squared = .379)

**Table 8b. Multiple comparison of differences between vegetation types for total browse productivity, Northeast Region Benchmark Program**

| | | | | | | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| Dependent Variable | Vegetation type "I" | Vegetation type "J" | Difference between means for types "I" and "J" | Std. Error | Sig. | Lower Bound | Upper Bound |
| Browse productivity (lb/ac) - cube root transformation | Aspen/Hazelnut | Aspen/Rose | .3630 | .284 | .525 | -.3533 | 1.0794 |
| | | Aspen/Rose-blueberry | 2.5891* | .347 | .000 | 1.7446 | 3.4335 |
| | Aspen/Rose | Aspen/Hazelnut | -.3630 | .284 | .525 | -1.0794 | .3533 |
| | | Aspen/Rose-blueberry | 2.2260* | .347 | .000 | 1.3977 | 3.0543 |
| | Aspen/Rose-blueberry | Aspen/Hazelnut | -2.5891* | .347 | .000 | -3.4335 | -1.7446 |
| | | Aspen/Rose | -2.2260* | .347 | .000 | -3.0543 | -1.3977 |

Based on observed means.

*. The mean difference is significant at the .05 level.

### 3.3.1.5 Management implications: hypothesis tests of forage productivity

The hypothesis tests presented above indicate that there are differences in overall productivity for either grass and forb or browse forage productivity. The original hypotheses as stated could be further refined to consider only those forage species that are most likely to be grazed or browsed, i.e., those which are classed as “good” or “fair” forage, without reference to the layer in which they occur.

If an ANOVA is conducted with this type of stratification, the statistical differences between vegetation types are the same (Table 9, boldfaced line). For the (good+fair) and poor forage quality classes, there are significant differences in productivity between vegetation types, as the significance values of 0.002 and 0.000 are less than the critical level of p=0.05.

**Table 9. Analysis of variance: Overall differences between vegetation types by forage quality class, Eastern Slopes Benchmark Program**

Dependent Variable: Total forage productivity (lbs/ac) - cube root transformation

| Forage quality | Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Good and fair | Corrected Model | 25.731[a] | 11 | 2.339 | 1.749 | .076 |
| | Intercept | 6856.475 | 1 | 6856.475 | 5126.185 | .000 |
| | **Vegetation type** | **17.869** | **2** | **8.934** | **6.680** | **.002** |
| | YEAR | .688 | 3 | .229 | .172 | .915 |
| | Interaction between vegetation type and year | 7.510 | 6 | 1.252 | .936 | .474 |
| | Error | 117.703 | 88 | 1.338 | | |
| | Total | 8007.677 | 100 | | | |
| | Corrected Total | 143.434 | 99 | | | |
| Poor | Corrected Model | 65.155[b] | 11 | 5.923 | 3.859 | .000 |
| | Intercept | 4829.949 | 1 | 4829.949 | 3146.447 | .000 |
| | **Vegetation type** | **55.129** | **2** | **27.564** | **17.957** | **.000** |
| | YEAR | 2.755 | 3 | .918 | .598 | .618 |
| | Interaction between vegetation type and year | 6.410 | 6 | 1.068 | .696 | .654 |
| | Error | 135.084 | 88 | 1.535 | | |
| | Total | 5341.005 | 100 | | | |
| | Corrected Total | 200.240 | 99 | | | |

[a] R Squared = .179 (Adjusted R Squared = .077)

[b] R Squared = .325 (Adjusted R Squared = .241)

Table 9 does not indicate what the differences are between individual vegetation types. Multiple range tests are useful tools for pinpointing the differences between different treatments if the overall ANOVA is significant. Table A3-1 in Appendix 3 provides a “post-hoc” multiple comparison of the three types based on a conservative test. In summary, the Aspen/Rose-blueberry type is less productive for (good+fair) forage than either of the other two types. The Aspen/Hazelnut type is less productive of poor quality forage than either of the other two types.

Within forage quality groups, are there any significant differences between forage layers? A similar ANOVA and multiple comparison test was conducted for all combinations of forage quality and forage type, and the detailed tables are provided in Appendix 3 (Table A3-2: ANOVA; Table A3-3: multiple range test). All comparisons for all but the poor quality shrub-twig layer are

significant at p=0.05; there are, therefore, differences between at least two of the vegetation types. There are no significant year effects, nor are there any significant interaction effects.

The multiple comparison test (Table A3-3) shows the following trends:

**Good quality forb:** (Aspen/Rose = Aspen/Rose-blueberry) > Aspen/Hazelnut
**Good quality grass:** Aspen/Rose-blueberry > Aspen/Rose > Aspen/Hazelnut
**Good quality shrub(leaf):** Aspen/Hazelnut > Aspen/Rose > Aspen/Rose-blueberry
**Good quality shrub(twig):** (Aspen/Rose = Aspen/Hazelnut) > Aspen/Rose-blueberry
**Poor quality forb:** Aspen/Rose-blueberry > (Aspen/Rose=Aspen/Hazelnut)
**Poor quality shrub(leaf):** Aspen/Rose > (Aspen/Hazelnut=Aspen/Rose-blueberry)
**Poor quality shrub(twig):** Aspen/Rose = Aspen/Hazelnut = Aspen/Rose-blueberry
**Litter:** Aspen/Rose > (Aspen/Hazelnut = Aspen/Rose-blueberry)
(an equal sign indicates no significant productivity difference, a greater than sign indicates significantly greater productivity)

Given the wide productivity ranges for individual species indicated above in the section on reliability assessments (Table 5), ANOVAs were not performed for individual species.

### 3.3.2 Effect of shrub cover on forage productivity (Hypothesis 3).

Downing and Karpuk (1992), in their discussion of vegetation trends in the Dry Boreal Mixedwood Subregion, pointed out a negative relationship between forb cover and shrub cover; with increasing shrub cover, forb cover decreased. Previous summary reports for the Northeast Benchmark program have noted a possible relationship between shrub cover and forage productivity. Hypothesis 3 (Section 2) was prepared with this relationship in mind, and addresses the effects of alder and willow cover on forage productivity in the program area. Downing and Karpuk (1992) indicated that one main cause of this relationship was the dominance of hazelnut (*Corylus cornuta*), which has a dense overlapping canopy growth form.

#### 3.3.2.1 Statement of Hypothesis.

(3) Forb and grass productivity is not affected by shrub cover and shrub type.

#### 3.3.2.2 Hypothesis test method.

There are two alternatives to testing the above hypothesis. One would be to arbitrarily assign a value that would separate plots having “light” shrub cover from those having “heavy” shrub cover and compare mean forage productivity values regardless of vegetation type. The second alternative would be to regress the productivity values on shrub cover estimates and attempt to refine the relationship indicated by Downing and Karpuk (1992). The latter is intuitively more objective than the former as it does not require the choice of an arbitrary value. The regression approach was chosen for this reason.

#### 3.3.2.3 Hypothesis test results.

Figure 6 shows the graphic results of linear regression analysis. The regression relationship (not shown) is highly significant (F statistic= 24.32, significance <<0.001). This means that the null hypothesis of no relationship between shrub cover and forage productivity is rejected. The graph shows that there is a negative relationship between hazelnut cover and grass/forb productivity regardless of vegetation type, and that there appears to be a significant change in the slope of the line when hazelnut cover reaches 40 percent. The adjusted $R^2$ value for the quadratic relationship is 0.29, which means that 29% of the variation in productivity can be “explained” by hazelnut cover.

The negative relationship between hazelnut cover and grass/forb productivity can be quantified as follows:

**Total productivity=599.3 –1.48*(hazelnut cover in %) – 0.07*(hazelnut cover in %)**

As a rule of thumb, if the cover of hazelnut exceeds 40 percent, average grass and forb forage productivity can be expected to decline by about half.

### 3.3.3 Comparison of forage productivity between the Eastern Slopes Region and Northeast Region Benchmark Program Areas (Hypothesis 4)

A cursory examination of previous summaries for both the Eastern Slopes Region and Northeast Region Benchmark Programs indicates that there are probably differences in productivity between the two areas. Hypothesis (4) above was developed to test this possibility. Figure 7 shows that, on average for all years in which data was collected for all plots within both program areas, the difference in average total productivity is about 162 lb/ac. When forage quality classes are considered (Figure 8), there are evident differences; poor quality forage productivity is about the same between program areas, but good quality forage productivity appears to be greater in the Northeast program area.

#### 3.3.3.1 Statement of hypothesis.

(4) There is no difference between the Dry Boreal Mixedwood and Lower Foothills natural subregions in terms of overall deciduous range productivity.

#### 3.3.3.2 Hypothesis test method

Total forage productivity by forage quality class was compared for the two areas using a t-test procedure and cube-root transformed data (refer to the methods section for a discussion of transformations).

#### 3.3.3.3 Results of hypothesis test

Table 10 presents the results of the t-test, and shows that there is a significant difference in forage productivity between the two program areas (test significant at $p=0.05$). The null hypothesis is rejected.

Management implications

These results do not necessarily mean that forage productivity is significantly greater overall in the Northeast compared to the Eastern Slopes; to safely make this conclusion, the relative areas

occupied by each vegetation type contributing to good and fair or poor forage quality classes would need to be known.

Figure 7. Comparison of total forage productivity between program areas

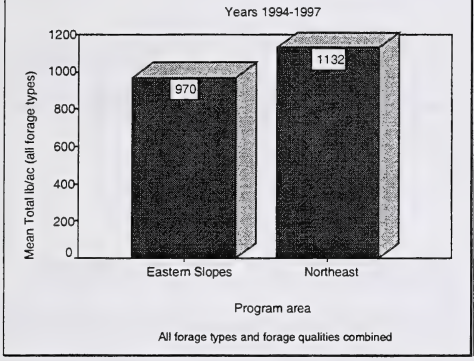
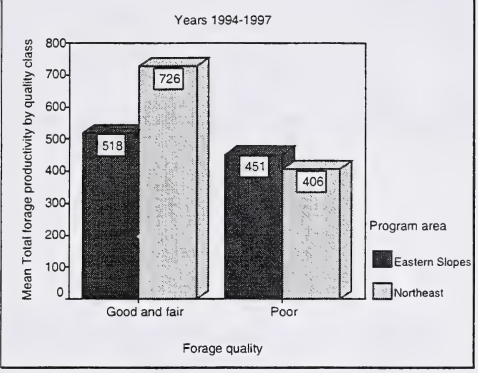


Figure 8. Comparison of forage productivity by forage quality between program areas



If two more or less equivalent and widespread vegetation types are compared, a significant difference between total forage productivity remains. Figure 8 presents a comparison of forage productivity for the Aspen/Rose vegetation type; this type occurs on similar sites in both program areas (that is, in the Eastern Slopes/Lower Foothills subregion and Northeast/Dry Boreal Mixedwood subregion). Table 11 shows a t-test comparison of the Aspen/Rose vegetation type, which represents modal ecological conditions (occupies similar sites) within the two areas.

The main management implication of this finding is that it is likely unwise to directly apply the findings of research in one natural subregion to another without calibrating the possible differences due to factors such as climate variation.

**Table 10. T-test of difference of means between Northeast Benchmark Program Plots and Eastern Slopes Benchmark Program Plots 1994-1997**

Cube-root transformed forage productivity

| | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | 95% Confidence Interval of the Difference | |
| | t | df | **Sig. (2-tailed)** | Mean Difference | Std. Error Difference | Lower | Upper |
| Equal variances assumed | 3.252 | 195 | **.001** | .5624 | .1729 | .2214 | .9035 |
| Equal variances not assumed | 3.248 | 192.282 | **.001** | .5624 | .1732 | .2209 | .9040 |

**Table 11. T-Test for difference of means between modal (Aspen/Rose) vegetation types in the Northeast and Eastern Slopes Benchmark Program Areas**

Cube-root transformed forage data

| | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | 95% Confidence Interval of the Difference | |
| | t | df | **Sig. (2-tailed)** | Mean Difference | Std. Error Difference | Lower | Upper |
| Equal variances assumed | 2.902 | 75 | **.005** | .8213 | .2830 | .2575 | 1.3852 |
| Equal variances not assumed | 2.904 | 74.726 | **.005** | .8213 | .2828 | .2579 | 1.3848 |

# 4 SUMMARY AND CONCLUSIONS.

Table 12 presents an overall summary of the productivity findings for the Northeast Region Benchmark Program; these results pertain to native aspen rangeland in good to excellent condition. Major elements of the data are summarized as follows in the table.

(1) Average dry weight productivity (lb/ac) for good and fair forage quality classes in aggregate (includes all forage types i.e. forb, grass, shrub-leaf, shrub-twig).

(2) Average dry weight productivity (lb/ac) for the poor forage quality class (litter is not included).

(3) Average dry weight productivity for good and fair forage quality classes (grasses and forbs only)

(4) Average dry weight productivity for poor forage quality classes (grasses and forbs only).

(5) The ratio of (good+fair) to poor quality forage. This ratio is useful for comparing vegetation types on a quantitative basis meaningful to range managers, as total productivity alone does not necessarily reflect the availability of usable forage.

(6) The amount of usable forage at a utilization rate of 50% of total (good+fair) forage and the number of AUMs/acre[6] that could be sustained at this utilization level.

The Aspen/Rose and Aspen/Hazelnut types are more productive on average than the Aspen/Rose-blueberry type *when browse is included*, and have a higher proportion of good to fair vs. poor forage than the latter type. When browse is excluded, the Aspen/Rose and Aspen/Rose-blueberry types are more productive on average than the Aspen/Hazelnut type.

With respect to stocking rates, under a conservative range management strategy, it would be appropriate to set stocking rates at a level that is not likely to have a negative impact on the range ecosystem even in years of poor production. Moreover, because productivity varies markedly throughout the season, stocking rates calculated from the data presented in this report should be considered as maximum stocking rates, as forage data were collected during the most productive period of the growing season. Areas with very heavy shrub cover are likely less productive, and cattle are less likely to use forage that occurs in patches surrounded or isolated by heavy shrub cover because of the 'barrier effect' (Ehlert, pers. comm.). Areas that have received moderate to heavy grazing pressure and that do not have a healthy cover of decreaser and increaser species will have lower carrying capacities than those reported here. The three vegetation types discussed in this report can be fairly reliably classified by the range manager or grazing lessee with some training, on the basis of shrub cover characteristics as presented in Table 2: Key to aspen vegetation types, east-central portion of Low Boreal Mixedwood Ecoregion (Downing and Karpuk 1992).

Under these assumptions, a recommended conservative management strategy would be to consider the following stocking rates:

- **3.1 acres/AUM for good to excellent condition Aspen/Rose stands;**
- **3.1 acres/AUM for good to excellent condition Aspen/Hazelnut stands having less than 40 percent hazelnut cover;**
- **6.2 acres/AUM for Aspen/Hazelnut stands having greater than 40 percent hazelnut cover; and,**
- **4.8 acres/AUM for Aspen/Rose-blueberry stands.**

If the vegetation type cannot reliably be determined, a stocking rate of 5 acres/AUM is recommended.

The results presented in this report are of potential value to range managers for the following reasons:

- There is good evidence on which to base a safe carrying capacity for native range in good to excellent condition. If community types can be reliably determined by range managers and lessees, safe levels of grazing can be determined on the basis of that determination. For about 60 to 70 percent of cases, it should be possible to assign aspen forests within a lease or grazing reserve to one of the three community types based on shrub characteristics. Otherwise, for native aspen range in good to excellent condition which cannot readily be assigned to a community type, a recommended conservative level of stocking is 5

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[6] AUM=animal unit month. Assuming a consumption rate of 33.4 lb/day (dry weight) for a cow-calf unit and an average month of 30 days, one AUM equates to 1000 lb dry weight usable forage. An average total dry weight production of 500 lb usable forage/acre would therefore support one animal unit for 0.5 months on one acre (2 acres/AUM).

acres/AUM, given a safe-use factor of 50 percent of good to fair quality forage and an AUM of 1000 lbs/month dry forage.

- The results provide a benchmark against which the magnitude and direction of departures caused by grazing or other land management activity can be assessed. If plant composition changes significantly, and/or if forage productivity declines below some established limit (e.g. 75 percent of productivity in a poor year), then modifications to range management practices might be indicated. In other words, grazed native aspen range should be managed so that aspen communities retain their ecological function and structure within the natural range that can be expected given year-to-year climatic variations in a specific natural subregion.
- All three types have similar species diversity based on total counts, and compositions of the more common species are also similar; it is the proportions of species that appear to be variable.
- In addition to forage productivity, there are of course other values associated with each of the native aspen community types. These are discussed by Downing and Karpuk (1992) who describe these types in terms of forest productivity, wildlife habitat values, and recreation capability. If these types are managed for forage productivity under a conservative regime, it is likely that other values would not be severely impacted. However, it would still be valuable to know what the approximate proportion of each community type or its ecosite equivalent is within a given management unit to facilitate the incorporation of other resource factors when grazing management plans are being developed.

A logical next step in this program would be to design an experiment to test the effects of controlled grazing on forage productivity on good to excellent range. The benchmark plots could form the experimental unit; possibly, cattle could be released within each plot for a set period of time, and forage productivity could be compared before grazing, immediately after grazing, and one year after grazing to assess trends in plant productivity and species composition. As well, data on forage quality recently collected by Alberta Agriculture in the St. Paul area could be used to refine species assignments to “good”, “fair” and “poor” quality classes.

Table 12. Summary of productivity information by community type, Northeast Region Benchmark Program, 1992-1997.

| **Community type** | **Aspen/rose/forb (10 plots)** | | | **Aspen/hazelnut/sarsaparilla (10 plots)** | | | **Aspen/rose/blueberry (5 plots)** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Summary of characteristics** | All years | Most productive year | Least productive year | All years | Most productive year | Least productive year | All years | Most productive year | Least productive year |
| **Total avg. Productivity (lb/ac dry weight):** | | | | | | | | | |
| **Good and fair quality forage (all types, including shrub-leaf and shrub-twig classes** | 767 | 908 (1994) | 643 (1992) | 807 | 987 (1993) | 726 (1995) | 519 | 584 (1997) | 419 (1994) |
| **Poor quality forage (litter not included)** | 349 | 463 (1997) | 343 (1992) | 244 | 296 (1993) | 210 (1995) | 462 | 515 (1997) | 391 (1994) |
| **Good and fair quality forage (*forbs and grasses only*)** | 370 | 455 (1994) | 305 (1997) | 188 | 260 (1993) | 141 (1997) | 387 | 432 (1996) | 349 (1994) |
| **Poor quality forage (forbs and grasses only)** | 224 | 274 (1992) | 185 (1995) | 205 | 244 (1993) | 174( 1995) | 381 | 413 (1996) | 319 (1994) |
| **Ratio of (good+fair) to poor quality forage expressed as percent of total forage (litter not included, *all other layers included*)** | 69:31 | 66:34 | 65:35 | 77:23 | 77:23 | 77:23 | 53:47 | 53:47 | 52:48 |
| **50% usable forage (lb/ac) (good+fair quality forage only)** | 383 | 454 | 321 | 403 | 493 | 363 | 259 | 292 | 210 |
| **Acres/AUM (maximum carrying capacity)** | 2.6 | 2.2 | 3.1 | 2.5 | 2.0 | 2.8 | 3.9 | 3.4 | 4.8 |

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# APPENDIX 1 FORAGE VALUE

* Not all species listed; default assignment is "fair" forage quality.
Codes follow *Alberta Plants and Fungi – Master Species List and Species Group Checklists* (Alberta Forestry Lands and Wildlife 1992).

| Species code | Forage value |
|---|---|
| ACHIMIL | poor |
| ACTARUB | fair |
| AGROREP | fair |
| AGROSCA | poor |
| AGROSTO | fair |
| AGROSUB | good |
| AGROTRA | good |
| ALNUCRI | poor |
| ALNUTEN | poor |
| ALOPAEQ | poor |
| ALOPPRA | good |
| AMELALN | good |
| ANEMCAN | fair |
| ANTEANA | poor |
| ARALNUD | poor |
| ARCTUVA | poor |
| ASTECIL | fair |
| ASTECON | good |
| BECKSYZ | fair |
| BETUGLA | poor |
| BETUPAP | poor |
| BROMCIL | good |
| BROMINE | good |
| BROMPUR | good |
| CALACAN | fair |
| CALAINE | fair |
| CALALON | fair |
| CALARUB | fair |
| CAREAQU | poor |
| CAREATH | good |
| CAREROS | good |
| CARESPP | fair |
| CASTMIN | poor |
| CERANUT | fair |
| CIRSARV | poor |
| CLINBOR | good |
| COMAUMB | poor |
| CORNCAN | poor |
| CORNSTO | good |
| CORYAUR | poor |
| CORYCOR | fair |
| DANTINT | fair |
| DELPGLA | poor |
| DESCCAE | good |
| DISPTRA | good |
| ELAECOM | poor |
| ELYMINN | fair |
| EPILANG | fair |
| EQUIARV | poor |
| EQUIPRA | poor |
| EQUISYL | poor |
| EQUIVAR | poor |
| FESTOVI | fair |
| FRAGVIR | poor |
| GALITRI | fair |
| GLYCBOR | good |
| HEDYALP | good |
| HEDYBOR | good |
| HERALAN | fair |
| HEUCRIC | poor |
| HIERODO | fair |
| HORDJUB | fair |
| JUNCBAL | poor |
| JUNICOM | poor |
| JUNIHOR | poor |
| LATHOCH | good |
| LATHVEN | good |
| LEDUGRO | poor |
| LEPISPP | poor |
| LILIPHI | fair |
| LINNBOR | poor |
| LONIDIO | poor |
| LONIINV | poor |
| LUZUPAR | good |
| MAIACAN | fair |
| MERTPAN | good |
| MITENUD | poor |
| ORYZASP | good |
| ORYZPUN | good |
| OSMOLON | good |
| PETAPAL | poor |
| PETASAG | poor |
| PETAVIT | poor |
| PHALARU | good |
| PHLEPRA | good |
| POA SPP | good |
| POACOMP | good |
| POAPRAT | good |
| POPUBAL | fair |
| POPUTRE | good |
| POTEANS | poor |
| POTESPP | poor |
| POTETRI | poor |
| PRUNPEN | fair |
| PRUNVIR | fair |
| PUCCNUT | good |
| PYROASA | poor |
| PYROCHL | poor |
| PYROELL | poor |
| PYROMIN | poor |
| RANUSPP | poor |
| RIBEOXY | poor |
| RIBETRI | poor |
| ROSAACI | fair |
| ROSAWOO | fair |
| RUBUIDA | fair |
| RUBUPUB | poor |
| RUMESPP | poor |
| SALIBEB | good |
| SANIMAR | fair |
| SCHIPUR | fair |
| SCOLFES | good |
| SENEPAP | poor |
| SHEPCAN | poor |
| SMILRAC | good |
| SOLICAN | fair |
| SONCARV | poor |
| SPIRBET | poor |
| SYMPALB | poor |
| SYMPOCC | poor |
| TANAVUL | poor |
| TARAOFF | fair |
| THALVEN | fair |
| TRIFHYB | good |
| TRIFPRA | good |
| TRIFREP | good |
| VACCCAE | poor |
| VACCMYR | poor |
| VACCVIT | poor |
| VIBUEDU | good |
| VIBUOPU | good |
| VICIAME | good |
| VIOLCAN | fair |
| VIOLNEP | fair |

## APPENDIX 2. Results of normality tests for raw biomass data and cube root transformation (some statistics omitted for brevity)

The table below presents the results of a test for normality that produces a normally-distributed statistic (Kolmogorov-Smirnov Z). The row labelled "Asymp. Sig. (2-tailed)" indicates the probability that the distribution is normal; if the value is less than 0.05, this indicates that the likelihood of normality is small. Either a cube root transformation or untransformed data would likely be acceptable; , however, a cube-root transformation was applied to these analyses because it does meet normality criteria for all three vegetation types.

**One-Sample Kolmogorov-Smirnov Test of Normality - untransformed and cube-root transformed forage data, all layers combined, Northeast Region Benchmark Program**

| Vegetation type | | | Total lb/ac (all forage types) | Cube-root transformed data |
|---|---|---|---|---|
| 1 Aspen/Hazelnut | N | | 40 | 40 |
| | Normal Parameters[a,b] | Mean | 1041.1781 | 9.9813 |
| | | Std. Deviation | 357.8882 | 1.1636 |
| | Most Extreme Differences | Absolute | .116 | .091 |
| | | Positive | .116 | .091 |
| | | Negative | -.066 | -.083 |
| | Kolmogorov-Smirnov Z | | .733 | .573 |
| | Asymp. Sig. (2-tailed) | | .655 | .898 |
| 2 Aspen/Rose | N | | 40 | 40 |
| | Normal Parameters[a,b] | Mean | 1259.0134 | 10.6304 |
| | | Std. Deviation | 432.5576 | 1.2518 |
| | Most Extreme Differences | Absolute | .139 | .115 |
| | | Positive | .139 | .115 |
| | | Negative | -.078 | -.097 |
| | Kolmogorov-Smirnov Z | | .876 | .728 |
| | Asymp. Sig. (2-tailed) | | .426 | .665 |
| 3 Aspen/Rose-blueberry | N | | 20 | 20 |
| | Normal Parameters[a,b] | Mean | 1060.1241 | 10.1230 |
| | | Std. Deviation | 224.1913 | .7327 |
| | Most Extreme Differences | Absolute | .122 | .133 |
| | | Positive | .095 | .085 |
| | | Negative | -.122 | -.133 |
| | Kolmogorov-Smirnov Z | | .546 | .595 |
| | Asymp. Sig. (2-tailed) | | .926 | .871 |

[a] Test distribution is Normal.

[b] Calculated from data.

# APPENDIX 3. SUMMARY OF ANALYSIS OF VARIANCE RESULTS: COMPARISON OF VEGETATION TYPES

The table below presents the results of post-hoc multiple range tests that indicate trends within forage quality types. Tamhanes' T2 test is a conservative (does not assume equal variances) pairwise comparison test based on a T-test (SPSS 1998). Stars indicate significant differences. Mean differences are expressed as differences between vegetation types represented as transformed (cube root) data.

**Table A3-1. Multiple comparison of vegetation types for (good+fair) and poor forage quality classes, Northeast Region Benchmark Program**

Dependent Variable: Total forage productivity (lbs/ac) - cube root transformation

Tamhane

| Forage quality | (I) Vegetation type | (J) Vegetation type | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|---|
| Good and fair | Aspen/Hazelnut | Aspen/Rose | -.1199 | .259 | .963 | -.7937 | .5539 |
| | | Aspen/Rose-blueberry | .9883* | .317 | .000 | .4137 | 1.5629 |
| | Aspen/Rose | Aspen/Hazelnut | .1199 | .259 | .963 | -.5539 | .7937 |
| | | Aspen/Rose-blueberry | 1.1082* | .317 | .000 | .5243 | 1.6921 |
| | Aspen/Rose-blueberry | Aspen/Hazelnut | -.9883* | .317 | .000 | -1.5629 | -.4137 |
| | | Aspen/Rose | -1.1082* | .317 | .000 | -1.6921 | -.5243 |
| Poor | Aspen/Hazelnut | Aspen/Rose | -1.2900* | .277 | .000 | -2.0005 | -.5795 |
| | | Aspen/Rose-blueberry | -1.8135* | .339 | .000 | -2.5168 | -1.1103 |
| | Aspen/Rose | Aspen/Hazelnut | 1.2900* | .277 | .000 | .5795 | 2.0005 |
| | | Aspen/Rose-blueberry | -.5235 | .339 | .156 | -1.1813 | .1343 |
| | Aspen/Rose-blueberry | Aspen/Hazelnut | 1.8135* | .339 | .000 | 1.1103 | 2.5168 |
| | | Aspen/Rose | .5235 | .339 | .156 | -.1343 | 1.1813 |

Based on observed means.

*. The mean difference is significant at the .05 level.

**Table A3-2. Analysis of variance: Forage productivity for three vegetation types organized by forage quality and type Northeast Region Benchmark Program**

Dependent Variable: Total forage productivity (lbs/ac) - cube root transformation

| Forage quality | Forage layer | Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|---|
| Good and fair | Forb | Corrected Model | 43.280$^{b}$ | 11 | 3.935 | 3.087 | .002 |
| | | Intercept | 2755.184 | 1 | 2755.184 | 2161.372 | .000 |
| | | **Vegetation type** | **38.026** | **2** | **19.013** | **14.915** | **.000** |
| | | YEAR | 2.793 | 3 | .931 | .730 | .537 |
| | | Interaction between vegetation type and year | 1.722 | 6 | .287 | .225 | .968 |
| | | Error | 112.177 | 88 | 1.275 | | |
| | | Total | 3193.448 | 100 | | | |
| | | Corrected Total | 155.456 | 99 | | | |
| | Grasses/grasslike | Corrected Model | 100.918$^{c}$ | 11 | 9.174 | 6.407 | .000 |
| | | Intercept | 1825.197 | 1 | 1825.197 | 1274.711 | .000 |
| | | **Vegetation type** | **93.104** | **2** | **46.552** | **32.512** | **.000** |
| | | YEAR | .886 | 3 | .295 | .206 | .892 |
| | | Interaction between vegetation type and year | 6.024 | 6 | 1.004 | .701 | .649 |
| | | Error | 126.003 | 88 | 1.432 | | |
| | | Total | 2019.108 | 100 | | | |
| | | Corrected Total | 226.921 | 99 | | | |
| | Shrub-Leaf | Corrected Model | 158.999$^{a}$ | 11 | 14.454 | 8.540 | .000 |
| | | Intercept | 3325.140 | 1 | 3325.140 | 1964.650 | .000 |
| | | **Vegetation type** | **136.303** | **2** | **68.151** | **40.267** | **.000** |
| | | YEAR | 16.740 | 3 | 5.580 | 3.297 | .024 |
| | | Interaction between vegetation type and year | 10.109 | 6 | 1.685 | .995 | .434 |
| | | Error | 148.939 | 88 | 1.692 | | |
| | | Total | 4459.118 | 100 | | | |
| | | Corrected Total | 307.938 | 99 | | | |
| | Shrub-Twig | Corrected Model | 45.505$^{b}$ | 11 | 4.137 | 3.081 | .002 |
| | | Intercept | 1601.757 | 1 | 1601.757 | 1192.856 | .000 |
| | | **Vegetation type** | **39.651** | **2** | **19.826** | **14.764** | **.000** |
| | | YEAR | 1.903 | 3 | .634 | .472 | .702 |
| | | Interaction between vegetation type and year | 3.832 | 6 | .639 | .476 | .825 |
| | | Error | 118.166 | 88 | 1.343 | | |
| | | Total | 2119.454 | 100 | | | |
| | | Corrected Total | 163.671 | 99 | | | |
| Poor | Forb | Corrected Model | 43.619$^{e}$ | 11 | 3.965 | 3.851 | .000 |
| | | Intercept | 3469.689 | 1 | 3469.689 | 3369.723 | .000 |
| | | **Vegetation type** | **37.916** | **2** | **18.958** | **18.412** | **.000** |
| | | YEAR | .401 | 3 | .134 | .130 | .942 |
| | | Interaction between vegetation type and year | 4.135 | 6 | .689 | .669 | .675 |
| | | Error | 90.611 | 88 | 1.030 | | |
| | | Total | 3746.733 | 100 | | | |
| | | Corrected Total | 134.230 | 99 | | | |
| | Shrub-Leaf | Corrected Model | 65.464$^{d}$ | 11 | 5.951 | 2.635 | .006 |
| | | Intercept | 957.069 | 1 | 957.069 | 423.790 | .000 |
| | | **Vegetation type** | **47.354** | **2** | **23.677** | **10.484** | **.000** |
| | | YEAR | 10.542 | 3 | 3.514 | 1.556 | .206 |
| | | Interaction between vegetation type and year | 6.684 | 6 | 1.114 | .493 | .812 |
| | | Error | 198.735 | 88 | 2.258 | | |
| | | Total | 1348.046 | 100 | | | |
| | | Corrected Total | 264.199 | 99 | | | |
| | Shrub-Twig | Corrected Model | 13.886$^{f}$ | 11 | 1.262 | .739 | .699 |
| | | Intercept | 358.894 | 1 | 358.894 | 210.077 | .000 |
| | | **Vegetation type** | **6.336** | **2** | **3.168** | **1.854** | **.163** |
| | | YEAR | 2.202 | 3 | .734 | .430 | .732 |
| | | Interaction between vegetation type and year | 5.821 | 6 | .970 | .568 | .755 |
| | | Error | 150.339 | 88 | 1.708 | | |
| | | Total | 552.788 | 100 | | | |
| | | Corrected Total | 164.224 | 99 | | | |
| | Litter | Corrected Model | 44.281$^{g}$ | 11 | 4.026 | 2.073 | .031 |
| | | Intercept | 1387.926 | 1 | 1387.926 | 714.882 | .000 |
| | | **Vegetation type** | **36.793** | **2** | **18.397** | **9.476** | **.000** |
| | | YEAR | 1.507 | 3 | .502 | .259 | .855 |
| | | Interaction between vegetation type and year | 4.229 | 6 | .705 | .363 | .900 |
| | | Error | 170.850 | 88 | 1.941 | | |
| | | Total | 1758.063 | 100 | | | |
| | | Corrected Total | 215.131 | 99 | | | |

a. R Squared = .516 (Adjusted R Squared = .456)

b. R Squared = .278 (Adjusted R Squared = .188)

c. R Squared = .445 (Adjusted R Squared = .375)

d. R Squared = .248 (Adjusted R Squared = .154)

e. R Squared = .325 (Adjusted R Squared = .241)

f. R Squared = .085 (Adjusted R Squared = -.030)

g. R Squared = .206 (Adjusted R Squared = .107)

**Table A3-3. Multiple comparisons of forage productivity between three vegetation types, organized by forage quality and type Northeast Regions Benchmark Program**

Dependent Variable: Total forage productivity (lbs/ac) - cube root transformation

Tamhane

| Forage quality | Forage layer | Vegetation type "I" | Vegetation type ""J" | Mean difference between "I" and "J" | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Good and fair | Forb | Aspen/Hazelnut | Aspen/Rose | -1.3716* | .252 | .000 | -2.0155 | -.7277 |
| | | | Aspen/Rose-blueberry | -.8442* | .309 | .001 | -1.3900 | -.2984 |
| | | Aspen/Rose | Aspen/Hazelnut | 1.3716* | .252 | .000 | .7277 | 2.0155 |
| | | | Aspen/Rose-blueberry | .5274 | .309 | .140 | -.1175 | 1.1724 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | .8442* | .309 | .001 | .2984 | 1.3900 |
| | | | Aspen/Rose | -.5274 | .309 | .140 | -1.1724 | .1175 |
| | Grasses/grasslike | Aspen/Hazelnut | Aspen/Rose | -1.1734* | .268 | .000 | -1.8752 | -.4717 |
| | | | Aspen/Rose-blueberry | -2.6110* | .328 | .000 | -3.1618 | -2.0602 |
| | | Aspen/Rose | Aspen/Hazelnut | 1.1734* | .268 | .000 | .4717 | 1.8752 |
| | | | Aspen/Rose-blueberry | -1.4376* | .328 | .000 | -2.0309 | -.8443 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | 2.6110* | .328 | .000 | 2.0602 | 3.1618 |
| | | | Aspen/Rose | 1.4376* | .328 | .000 | .8443 | 2.0309 |
| | Shrub-Leaf | Aspen/Hazelnut | Aspen/Rose | .9120* | .291 | .011 | .1692 | 1.6548 |
| | | | Aspen/Rose-blueberry | 3.1908* | .356 | .000 | 2.3223 | 4.0593 |
| | | Aspen/Rose | Aspen/Hazelnut | -.9120* | .291 | .011 | -1.6548 | -.1692 |
| | | | Aspen/Rose-blueberry | 2.2788* | .356 | .000 | 1.4425 | 3.1151 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | -3.1908* | .356 | .000 | -4.0593 | -2.3223 |
| | | | Aspen/Rose | -2.2788* | .356 | .000 | -3.1151 | -1.4425 |
| | Shrub-Twig | Aspen/Hazelnut | Aspen/Rose | .3386 | .259 | .502 | -.3117 | .9889 |
| | | | Aspen/Rose-blueberry | 1.6973* | .317 | .000 | 1.0114 | 2.3832 |
| | | Aspen/Rose | Aspen/Hazelnut | -.3386 | .259 | .502 | -.9889 | .3117 |
| | | | Aspen/Rose-blueberry | 1.3587* | .317 | .000 | .7327 | 1.9848 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | -1.6973* | .317 | .000 | -2.3832 | -1.0114 |
| | | | Aspen/Rose | -1.3587* | .317 | .000 | -1.9848 | -.7327 |
| Poor | Forb | Aspen/Hazelnut | Aspen/Rose | -.3471 | .227 | .369 | -.9207 | .2265 |
| | | | Aspen/Rose-blueberry | -1.6632* | .278 | .000 | -2.3298 | -.9967 |
| | | Aspen/Rose | Aspen/Hazelnut | .3471 | .227 | .369 | -.2265 | .9207 |
| | | | Aspen/Rose-blueberry | -1.3161* | .278 | .000 | -1.8263 | -.8060 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | 1.6632* | .278 | .000 | .9967 | 2.3298 |
| | | | Aspen/Rose | 1.3161* | .278 | .000 | .8060 | 1.8263 |
| | Shrub-Leaf | Aspen/Hazelnut | Aspen/Rose | -1.5245* | .336 | .000 | -2.2768 | -.7721 |
| | | | Aspen/Rose-blueberry | -.5283 | .412 | .595 | -1.7021 | .6455 |
| | | Aspen/Rose | Aspen/Hazelnut | 1.5245* | .336 | .000 | .7721 | 2.2768 |
| | | | Aspen/Rose-blueberry | .9961 | .412 | .157 | -.2651 | 2.2573 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | .5283 | .412 | .595 | -.6455 | 1.7021 |
| | | | Aspen/Rose | -.9961 | .412 | .157 | -2.2573 | .2651 |
| | Shrub-Twig | Aspen/Hazelnut | Aspen/Rose | -.5358 | .292 | .182 | -1.2343 | .1628 |
| | | | Aspen/Rose-blueberry | -.4608 | .358 | .432 | -1.2907 | .3691 |
| | | Aspen/Rose | Aspen/Hazelnut | .5358 | .292 | .182 | -.1628 | 1.2343 |
| | | | Aspen/Rose-blueberry | 7.495E-02 | .358 | .996 | -.8333 | .9832 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | .4608 | .358 | .432 | -.3691 | 1.2907 |
| | | | Aspen/Rose | -7.4953E-02 | .358 | .996 | -.9832 | .8333 |
| | Litter | Aspen/Hazelnut | Aspen/Rose | -1.3563* | .312 | .000 | -2.0784 | -.6342 |
| | | | Aspen/Rose-blueberry | -.6706 | .382 | .253 | -1.6442 | .3030 |
| | | Aspen/Rose | Aspen/Hazelnut | 1.3563* | .312 | .000 | .6342 | 2.0784 |
| | | | Aspen/Rose-blueberry | .6857 | .382 | .253 | -.3079 | 1.6793 |
| | | Aspen/Rose-blueberry | Aspen/Hazelnut | .6706 | .382 | .253 | -.3030 | 1.6442 |
| | | | Aspen/Rose | -.6857 | .382 | .253 | -1.6793 | .3079 |

Based on observed means.

*. The mean difference is significant at the .05 level.

(some information omitted for readability)

## Appendix 4. Reliability assessment summaries

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                MEAN AND RANGE OF BIOMASS (LB/AC) FOR TYPE AND VALUE OF FORAGE
               FOR NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS

------------- Confidence*level(%)=80 Vegetation type=AW/HAZEL --------------

                     Forage    Range for con-       %      Confidence
      Forage type    value     fidence level      error     level(%)

      1-Grass        1-Good     20.0 +/-   4.4      22          80
      1-Grass        2-Fair     29.7 +/-   4.7      16          80
      2-Forb         1-Good     77.7 +/-  11.4      15          80
      2-Forb         2-Fair     61.3 +/-   7.5      12          80
      2-Forb         3-Poor    204.6 +/-  22.0      11          80
      3-Shrub-Leaf   1-Good     96.3 +/-  31.3      32          80
      3-Shrub-Leaf   2-Fair    387.2 +/-  43.6      11          80
      3-Shrub-Leaf   3-Poor     29.5 +/-   6.7      23          80
      4-Shrub-Twig   1-Good     38.3 +/-  10.8      28          80
      4-Shrub-Twig   2-Fair     96.7 +/-  15.4      16          80
      4-Shrub-Twig   3-Poor     10.2 +/-   4.3      42          80
      5-Litter       3-Poor     51.6 +/-   8.1      16          80


-------------- Confidence*level(%)=80 Vegetation type=AW/ROSE --------------

                     Forage    Range for con-       %      Confidence
      Forage type    value     fidence level      error     level(%)

      1-Grass        1-Good      6.6 +/-   1.4      22          80
      1-Grass        2-Fair     98.6 +/-  19.3      20          80
      2-Forb         1-Good    127.9 +/-  13.8      11          80
      2-Forb         2-Fair    135.9 +/-  20.9      15          80
      2-Forb         3-Poor    224.0 +/-  13.5       6          80
      3-Shrub-Leaf   1-Good     95.5 +/-  14.7      15          80
      3-Shrub-Leaf   2-Fair    191.7 +/-  29.2      15          80
      3-Shrub-Leaf   3-Poor     90.2 +/-  22.7      25          80
      4-Shrub-Twig   1-Good     33.4 +/-   5.3      16          80
      4-Shrub-Twig   2-Fair     76.6 +/-  13.4      17          80
      4-Shrub-Twig   3-Poor     35.1 +/-  12.0      34          80
      5-Litter       3-Poor    110.5 +/-  17.5      16          80

--------- Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR ----------

                     Forage    Range for con-       %      Confidence
      Forage type    value     fidence level      error     level(%)

      1-Grass        1-Good    115.4 +/-  17.9      16          80
      1-Grass        2-Fair     87.1 +/-  14.2      16          80
      2-Forb         1-Good    117.8 +/-  15.4      13          80
      2-Forb         2-Fair     67.4 +/-   8.9      13          80
      2-Forb         3-Poor    381.3 +/-  35.4       9          80
      3-Shrub-Leaf   1-Good     29.1 +/-  11.5      40          80
      3-Shrub-Leaf   2-Fair     63.1 +/-  11.9      19          80
      3-Shrub-Leaf   3-Poor     62.0 +/-  23.0      37          80
      4-Shrub-Twig   1-Good      5.5 +/-   2.5      45          80
      4-Shrub-Twig   2-Fair     33.8 +/-   9.7      29          80
      4-Shrub-Twig   3-Poor     19.3 +/-   7.0      36          80
      5-Litter       3-Poor     78.4 +/-  12.0      15          80
```

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            MEAN AND RANGE OF BIOMASS (LB/AC) FOR TYPE AND VALUE OF FORAGE
              FOR NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS

------------- Confidence*level(%)=95 Vegetation type=AW/HAZEL --------------

                         Forage    Range for con-        %      Confidence
       Forage type       value     fidence level       error     level(%)

       1-Grass           1-Good     20.0 +/-   6.8       34          95
       1-Grass           2-Fair     29.7 +/-   7.3       25          95
       2-Forb            1-Good     77.7 +/-  17.7       23          95
       2-Forb            2-Fair     61.3 +/-  11.5       19          95
       2-Forb            3-Poor    204.6 +/-  34.0       17          95
       3-Shrub-Leaf      1-Good     96.3 +/-  48.4       50          95
       3-Shrub-Leaf      2-Fair    387.2 +/-  67.5       17          95
       3-Shrub-Leaf      3-Poor     29.5 +/-  10.4       35          95
       4-Shrub-Twig      1-Good     38.3 +/-  16.8       44          95
       4-Shrub-Twig      2-Fair     96.7 +/-  23.9       25          95
       4-Shrub-Twig      3-Poor     10.2 +/-   6.6       65          95
       5-Litter          3-Poor     51.6 +/-  12.6       24          95


-------------- Confidence*level(%)=95 Vegetation type=AW/ROSE --------------

                         Forage    Range for con-        %      Confidence
       Forage type       value     fidence level       error     level(%)

       1-Grass           1-Good      6.6 +/-   2.2       33          95
       1-Grass           2-Fair     98.6 +/-  29.8       30          95
       2-Forb            1-Good    127.9 +/-  21.3       17          95
       2-Forb            2-Fair    135.9 +/-  32.3       24          95
       2-Forb            3-Poor    224.0 +/-  20.8        9          95
       3-Shrub-Leaf      1-Good     95.5 +/-  22.7       24          95
       3-Shrub-Leaf      2-Fair    191.7 +/-  45.2       24          95
       3-Shrub-Leaf      3-Poor     90.2 +/-  35.0       39          95
       4-Shrub-Twig      1-Good     33.4 +/-   8.3       25          95
       4-Shrub-Twig      2-Fair     76.6 +/-  20.7       27          95
       4-Shrub-Twig      3-Poor     35.1 +/-  18.5       53          95
       5-Litter          3-Poor    110.5 +/-  27.0       24          95

--------- Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR ----------

                         Forage    Range for con-        %      Confidence
       Forage type       value     fidence level       error     level(%)

       1-Grass           1-Good    115.4 +/-  28.3       25          95
       1-Grass           2-Fair     87.1 +/-  22.4       26          95
       2-Forb            1-Good    117.8 +/-  24.3       21          95
       2-Forb            2-Fair     67.4 +/-  14.0       21          95
       2-Forb            3-Poor    381.3 +/-  55.8       15          95
       3-Shrub-Leaf      1-Good     29.1 +/-  18.1       62          95
       3-Shrub-Leaf      2-Fair     63.1 +/-  18.7       30          95
       3-Shrub-Leaf      3-Poor     62.0 +/-  36.2       58          95
       4-Shrub-Twig      1-Good      5.5 +/-   3.9       70          95
       4-Shrub-Twig      2-Fair     33.8 +/-  15.3       45          95
       4-Shrub-Twig      3-Poor     19.3 +/-  11.0       57          95
       5-Litter          3-Poor     78.4 +/-  19.0       24          95
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                 MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
               NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS

------------- Confidence*level(%)=80 Vegetation type=AW/HAZEL --------------

                      Range for con-       %      Confidence
     Forage type      fidence level      error     level(%)

     3-Shrub-Leaf     512.9 +/-  60.1      12          80
     2-Forb           343.6 +/-  36.2      11          80
     4-Shrub-Twig     145.2 +/-  21.1      15          80
     5-Litter          51.6 +/-   8.1      16          80
     1-Grass           49.7 +/-   8.1      16          80


-------------- Confidence*level(%)=80 Vegetation type=AW/ROSE --------------

                      Range for con-       %      Confidence
     Forage type      fidence level      error     level(%)

     2-Forb           487.8 +/-  36.0       7          80
     3-Shrub-Leaf     377.3 +/-  39.3      10          80
     4-Shrub-Twig     145.2 +/-  16.9      12          80
     5-Litter         110.5 +/-  17.5      16          80
     1-Grass          105.1 +/-  18.9      18          80


--------- Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR ----------

                      Range for con-       %      Confidence
     Forage type      fidence level      error     level(%)

     2-Forb           566.4 +/-  51.4       9          80
     1-Grass          202.5 +/-  15.1       7          80
     3-Shrub-Leaf     154.2 +/-  29.8      19          80
     5-Litter          78.4 +/-  12.0      15          80
     4-Shrub-Twig      58.6 +/-   9.6      16          80

------------- Confidence*level(%)=95 Vegetation type=AW/HAZEL --------------

                      Range for con-       %      Confidence
     Forage type      fidence level      error     level(%)

     3-Shrub-Leaf     512.9 +/-  92.9      18          95
     2-Forb           343.6 +/-  56.0      16          95
     4-Shrub-Twig     145.2 +/-  32.7      23          95
     5-Litter          51.6 +/-  12.6      24          95
     1-Grass           49.7 +/-  12.6      25          95

-------------- Confidence*level(%)=95 Vegetation type=AW/ROSE --------------

                      Range for con-       %      Confidence
     Forage type      fidence level      error     level(%)

     2-Forb           487.8 +/-  55.6      11          95
     3-Shrub-Leaf     377.3 +/-  60.6      16          95
     4-Shrub-Twig     145.2 +/-  26.1      18          95
```

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                MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
              NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


--------------- Confidence*level(%)=95 Vegetation type=AW/ROSE ---------------
                                  (continued)

                       Range for con-        %       Confidence
           Forage type    fidence level      error     level(%)

            5-Litter      110.5 +/-   27.0      24         95
            1-Grass       105.1 +/-   29.2      28         95


---------- Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR -----------

                           Range for con-        %       Confidence
           Forage type     fidence level      error     level(%)

           2-Forb          566.4 +/-   81.0      14         95
           1-Grass         202.5 +/-   23.8      12         95
           3-Shrub-Leaf    154.2 +/-   47.0      30         95
           5-Litter         78.4 +/-   19.0      24         95
           4-Shrub-Twig     58.6 +/-   15.2      26         95
```

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               MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE VALUE CLASSES
                 NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS

------------- Confidence*level(%)=80 Vegetation type=AW/HAZEL --------------

                 Forage     Range for con-        %      Confidence
                 value      fidence level       error     level(%)

                 2-Fair     574.9 +/-   50.8       9         80
                 3-Poor     295.8 +/-   30.5      10         80
                 1-Good     232.3 +/-   40.6      17         80


-------------- Confidence*level(%)=80 Vegetation type=AW/ROSE --------------

                 Forage     Range for con-        %      Confidence
                 value      fidence level       error     level(%)

                 2-Fair     502.8 +/-   45.9       9         80
                 3-Poor     459.7 +/-   43.0       9         80
                 1-Good     263.4 +/-   19.6       7         80


--------- Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR ----------

                 Forage     Range for con-        %      Confidence
                 value      fidence level       error     level(%)

                 3-Poor     541.0 +/-   46.3       9         80
                 1-Good     267.7 +/-   28.4      11         80
                 2-Fair     251.4 +/-   24.1      10         80


------------- Confidence*level(%)=95 Vegetation type=AW/HAZEL --------------

                 Forage     Range for con-        %      Confidence
                 value      fidence level       error     level(%)

                 2-Fair     574.9 +/-   78.5      14         95
                 3-Poor     295.8 +/-   47.2      16         95
                 1-Good     232.3 +/-   62.9      27         95

-------------- Confidence*level(%)=95 Vegetation type=AW/ROSE --------------

                 Forage     Range for con-        %      Confidence
                 value      fidence level       error     level(%)

                 2-Fair     502.8 +/-   70.8      14         95
                 3-Poor     459.7 +/-   66.3      14         95
                 1-Good     263.4 +/-   30.2      11         95

--------- Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR ----------

                 Forage     Range for con-        %      Confidence
                 value      fidence level       error     level(%)

                 3-Poor     541.0 +/-   73.0      13         95
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        MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE VALUE CLASSES
          NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


---------- Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR -----------
                                 (continued)

               Forage    Range for con-      %      Confidence
               value     fidence level      error    level(%)

               1-Good    267.7 +/-  44.8     17         95
               2-Fair    251.4 +/-  38.1     15         95
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                  MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
                NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


-- Confidence*level(%)=80 Vegetation type=AW/HAZEL Forage type=3-Shrub-Leaf --

                 Species    Range for con-       %      Confidence
                  code      fidence level      error     level(%)

                 CORYCOR    246.5 +/-  48.0      19         80
                 ROSAACI     54.7 +/-  15.6      29         80
                 POPUTRE     44.7 +/-  26.2      59         80
                 RUBUIDA     32.3 +/-  17.5      54         80
                 ROSAWOO     29.3 +/-  10.7      36         80
                 AMELALN     20.8 +/-   8.5      41         80
                 VIBUEDU     14.2 +/-   4.3      30         80
                 PRUNVIR     13.1 +/-   5.2      40         80
                 CORNSTO     11.4 +/-   5.8      51         80
                 SYMPALB      8.7 +/-   2.5      29         80
                 LONIDIO      8.4 +/-   5.0      60         80
                 SALIBEB      5.1 +/-   3.0      59         80


----- Confidence*level(%)=80 Vegetation type=AW/HAZEL Forage type=2-Forb -----

                 Species    Range for con-       %      Confidence
                  code      fidence level      error     level(%)

                 LATHOCH     59.0 +/-  10.6      18         80
                 ARALNUD     51.9 +/-   8.5      16         80
                 PYROASA     35.0 +/-  10.4      30         80
                 CORNCAN     31.1 +/-   5.0      16         80
                 LINNBOR     28.9 +/-   7.5      26         80
                 FRAGVIR     25.7 +/-   6.5      25         80
                 RUBUPUB     20.9 +/-   3.2      15         80
                 MAIACAN     16.3 +/-   2.2      14         80
                 EPILANG     12.5 +/-   4.1      33         80
                 GALIBOR     10.5 +/-   1.5      15         80
                 VICIAME      8.5 +/-   2.3      27         80
                 ASTECIL      8.2 +/-   1.7      20         80
                 PETAPAL      6.6 +/-   1.8      26         80
                 ASTECON      6.0 +/-   2.5      42         80

---- Confidence*level(%)=80 Vegetation type=AW/HAZEL Forage type=1-Grass -----

                 Species    Range for con-       %      Confidence
                  code      fidence level      error     level(%)

                 ORYZASP     16.6 +/-   3.9      23         80
                 ELYMINN     14.2 +/-   3.4      24         80
                 CALACAN     12.0 +/-   3.3      28         80

---- Confidence*level(%)=80 Vegetation type=AW/HAZEL Forage type=5-Litter ----

                 Species    Range for con-       %      Confidence
                  code      fidence level      error     level(%)

                 LITTER      51.6 +/-   8.1      16         80
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                    MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
                  NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


-- Confidence*level(%)=80 Vegetation type=AW/HAZEL Forage type=4-Shrub-Twig --

                  Species     Range for con-        %      Confidence
                   code       fidence level       error     level(%)

                  CORYCOR      45.4 +/-   13.1      29          80
                  RUBUIDA      22.1 +/-   10.5      47          80
                  ROSAACI      17.3 +/-    4.4      26          80
                  POPUTRE      12.7 +/-    7.2      57          80
                  ROSAWOO       9.1 +/-    3.5      39          80
                  SALIBEB       8.3 +/-    3.8      46          80
                  AMELALN       6.4 +/-    2.5      40          80
                  VIBUEDU       6.3 +/-    2.0      31          80


-- Confidence*level(%)=80 Vegetation type=AW/ROSE Forage type=3-Shrub-Leaf ---

                  Species     Range for con-        %      Confidence
                   code       fidence level       error     level(%)

                  ROSAACI      60.0 +/-   12.4      21          80
                  RUBUIDA      53.6 +/-   15.7      29          80
                  POPUTRE      46.6 +/-   12.2      26          80
                  ROSAWOO      45.7 +/-   11.0      24          80
                  ALNUCRI      25.9 +/-   19.9      77          80
                  SYMPALB      23.0 +/-    6.5      28          80
                  LONIINV      19.3 +/-    5.7      30          80
                  AMELALN      16.7 +/-    5.6      33          80
                  CORNSTO      14.9 +/-    5.0      33          80
                  VIBUEDU      13.2 +/-    4.2      32          80
                  CORYCOR      12.9 +/-   10.2      79          80
                  POPUBAL       9.9 +/-    6.6      67          80
                  LONIDIO       7.3 +/-    2.8      38          80
                  BETUPAP       5.8 +/-    4.7      81          80

----- Confidence*level(%)=80 Vegetation type=AW/ROSE Forage type=2-Forb ------

                  Species     Range for con-        %      Confidence
                   code       fidence level       error     level(%)

                  LATHOCH      76.4 +/-    7.3      10          80
                  EPILANG      75.6 +/-   22.0      29          80
                  ARALNUD      59.5 +/-   12.9      22          80
                  CORNCAN      39.3 +/-    3.9      10          80
                  FRAGVIR      37.1 +/-    3.9      11          80
                  VICIAME      29.3 +/-    5.4      19          80
                  PYROASA      27.0 +/-    4.5      17          80
                  RUBUPUB      26.1 +/-    3.6      14          80
                  LINNBOR      22.0 +/-    5.0      23          80
                  GALIBOR      18.5 +/-    2.7      15          80
                  LATHVEN      11.5 +/-    6.4      56          80
                  MAIACAN      10.7 +/-    1.4      13          80
                  PETAPAL       8.0 +/-    1.2      15          80
                  ASTECIL       7.6 +/-    1.2      15          80
```

```
                 MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
               NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


----- Confidence*level(%)=80 Vegetation type=AW/ROSE Forage type=1-Grass -----

              Species    Range for con-       %      Confidence
               code      fidence level      error     level(%)

              CALACAN     74.6 +/-  19.1      26         80
              ELYMINN     19.3 +/-   3.7      19         80


---- Confidence*level(%)=80 Vegetation type=AW/ROSE Forage type=5-Litter -----

              Species    Range for con-       %      Confidence
               code      fidence level      error     level(%)

              LITTER     110.5 +/-  17.5      16         80


-- Confidence*level(%)=80 Vegetation type=AW/ROSE Forage type=4-Shrub-Twig ---

              Species    Range for con-       %      Confidence
               code      fidence level      error     level(%)

              ROSAACI     24.9 +/-   5.0      20         80
              RUBUIDA     22.1 +/-   5.9      27         80
              ALNUCRI     15.7 +/-  11.4      72         80
              POPUTRE     15.0 +/-   4.2      28         80
              CORYCOR     12.8 +/-   9.2      72         80
              VIBUEDU      6.8 +/-   3.1      45         80
              ROSAWOO      6.3 +/-   2.4      39         80
              LONIINV      6.1 +/-   2.5      40         80
              POPUBAL      5.5 +/-   3.3      61         80
              AMELALN      5.0 +/-   1.7      35         80


Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR Forage type=3-Shrub-Leaf

              Species    Range for con-       %      Confidence
               code      fidence level      error     level(%)

              ROSAACI     43.5 +/-  11.2      26         80
              VACCMYR     25.5 +/-  20.1      79         80
              ROSAWOO     17.8 +/-  11.8      66         80
              AMELALN     13.0 +/-   9.5      73         80
              SYMPALB     11.1 +/-   5.9      54         80
              SHEPCAN     10.9 +/-  11.0     101         80
              SALIBEB      7.7 +/-   5.0      66         80
              POPUTRE      7.5 +/-   5.7      76         80
              LEDUGRO      6.8 +/-   6.5      95         80
              LONIINV      6.4 +/-   8.0     125         80
```

## MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
## NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS

- Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR Forage type=2-Forb -

| Species code | Range for confidence level | % error | Confidence level(%) |
|---|---|---|---|
| ARCTUVA | 97.7 +/- 52.2 | 53 | 80 |
| LATHOCH | 91.9 +/- 13.0 | 14 | 80 |
| LINNBOR | 83.7 +/- 15.4 | 18 | 80 |
| CORNCAN | 63.4 +/- 12.7 | 20 | 80 |
| FRAGVIR | 47.6 +/- 9.7 | 20 | 80 |
| PYROASA | 27.5 +/- 8.4 | 31 | 80 |
| VACCCAE | 24.7 +/- 7.3 | 30 | 80 |
| GALIBOR | 20.5 +/- 4.8 | 24 | 80 |
| MAIACAN | 13.4 +/- 2.8 | 21 | 80 |
| VICIAME | 13.2 +/- 3.1 | 24 | 80 |
| RUBUPUB | 11.8 +/- 4.2 | 35 | 80 |
| PETAPAL | 10.7 +/- 3.4 | 32 | 80 |
| ASTECIL | 9.9 +/- 2.1 | 21 | 80 |
| VACCVIT | 7.9 +/- 4.7 | 59 | 80 |
| ORTHSEC | 6.3 +/- 1.8 | 29 | 80 |
| TRIFPRA | 5.6 +/- 4.5 | 79 | 80 |
| SOLICAN | 5.1 +/- 6.8 | 131 | 80 |

Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR Forage type=1-Grass

| Species code | Range for confidence level | % error | Confidence level(%) |
|---|---|---|---|
| ORYZASP | 102.9 +/- 17.9 | 17 | 80 |
| ELYMINN | 55.1 +/- 7.5 | 14 | 80 |
| SCHIPUR | 15.9 +/- 7.3 | 46 | 80 |
| CARESPP | 7.8 +/- 2.5 | 32 | 80 |
| POAPRAT | 6.1 +/- 2.6 | 43 | 80 |

Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR Forage type=5-Litter

| Species code | Range for confidence level | % error | Confidence level(%) |
|---|---|---|---|
| LITTER | 78.4 +/- 12.0 | 15 | 80 |

Confidence*level(%)=80 Vegetation type=AW/ROSE/BLUEBERR Forage type=4-Shrub-Twig

| Species code | Range for confidence level | % error | Confidence level(%) |
|---|---|---|---|
| ROSAACI | 19.2 +/- 7.5 | 39 | 80 |
| VACCMYR | 10.3 +/- 6.6 | 64 | 80 |
| ROSAWOO | 9.6 +/- 5.3 | 56 | 80 |

```
             MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
            NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


-- Confidence*level(%)=95 Vegetation type=AW/HAZEL Forage type=3-Shrub-Leaf --

            Species    Range for con-        %      Confidence
             code      fidence level       error     level(%)

            CORYCOR    246.5 +/-  74.2       30          95
            ROSAACI     54.7 +/-  24.2       44          95
            POPUTRE     44.7 +/-  40.6       91          95
            RUBUIDA     32.3 +/-  27.1       84          95
            ROSAWOO     29.3 +/-  16.5       56          95
            AMELALN     20.8 +/-  13.2       63          95
            VIBUEDU     14.2 +/-   6.7       47          95
            PRUNVIR     13.1 +/-   8.0       61          95
            CORNSTO     11.4 +/-   9.0       78          95
            SYMPALB      8.7 +/-   3.9       44          95
            LONIDIO      8.4 +/-   7.8       93          95
            SALIBEB      5.1 +/-   4.7       91          95


----- Confidence*level(%)=95 Vegetation type=AW/HAZEL Forage type=2-Forb -----

            Species    Range for con-        %      Confidence
             code      fidence level       error     level(%)

            LATHOCH     59.0 +/-  16.3       28          95
            ARALNUD     51.9 +/-  13.1       25          95
            PYROASA     35.0 +/-  16.0       46          95
            CORNCAN     31.1 +/-   7.7       25          95
            LINNBOR     28.9 +/-  11.5       40          95
            FRAGVIR     25.7 +/-  10.0       39          95
            RUBUPUB     20.9 +/-   4.9       23          95
            MAIACAN     16.3 +/-   3.4       21          95
            EPILANG     12.5 +/-   6.3       51          95
            GALIBOR     10.5 +/-   2.4       23          95
            VICIAME      8.5 +/-   3.6       42          95
            ASTECIL      8.2 +/-   2.6       31          95
            PETAPAL      6.6 +/-   2.7       41          95
            ASTECON      6.0 +/-   3.8       64          95

---- Confidence*level(%)=95 Vegetation type=AW/HAZEL Forage type=1-Grass -----

            Species    Range for con-        %      Confidence
             code      fidence level       error     level(%)

            ORYZASP     16.6 +/-   6.0       36          95
            ELYMINN     14.2 +/-   5.2       37          95
            CALACAN     12.0 +/-   5.1       43          95

---- Confidence*level(%)=95 Vegetation type=AW/HAZEL Forage type=5-Litter ----

            Species    Range for con-        %      Confidence
             code      fidence level       error     level(%)

            LITTER      51.6 +/-  12.6       24          95
```

```
                 MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
               NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


-- Confidence*level(%)=95 Vegetation type=AW/HAZEL Forage type=4-Shrub-Twig --

              Species     Range for con-        %       Confidence
               code       fidence level       error      level(%)

              CORYCOR      45.4 +/-  20.3      45           95
              RUBUIDA      22.1 +/-  16.2      73           95
              ROSAACI      17.3 +/-   6.9      40           95
              POPUTRE      12.7 +/-  11.2      89           95
              ROSAWOO       9.1 +/-   5.5      60           95
              SALIBEB       8.3 +/-   5.9      72           95
              AMELALN       6.4 +/-   3.9      62           95
              VIBUEDU       6.3 +/-   3.1      48           95


-- Confidence*level(%)=95 Vegetation type=AW/ROSE Forage type=3-Shrub-Leaf ---

              Species     Range for con-        %       Confidence
               code       fidence level       error      level(%)

              ROSAACI      60.0 +/-  19.1      32           95
              RUBUIDA      53.6 +/-  24.2      45           95
              POPUTRE      46.6 +/-  18.9      40           95
              ROSAWOO      45.7 +/-  17.0      37           95
              ALNUCRI      25.9 +/-  30.7     119           95
              SYMPALB      23.0 +/-  10.0      43           95
              LONIINV      19.3 +/-   8.8      46           95
              AMELALN      16.7 +/-   8.6      52           95
              CORNSTO      14.9 +/-   7.7      51           95
              VIBUEDU      13.2 +/-   6.5      49           95
              CORYCOR      12.9 +/-  15.7     122           95
              POPUBAL       9.9 +/-  10.2     104           95
              LONIDIO       7.3 +/-   4.4      59           95
              BETUPAP       5.8 +/-   7.2     124           95

----- Confidence*level(%)=95 Vegetation type=AW/ROSE Forage type=2-Forb ------

              Species     Range for con-        %       Confidence
               code       fidence level       error      level(%)

              LATHOCH      76.4 +/-  11.3      15           95
              EPILANG      75.6 +/-  33.9      45           95
              ARALNUD      59.5 +/-  20.0      34           95
              CORNCAN      39.3 +/-   6.0      15           95
              FRAGVIR      37.1 +/-   6.0      16           95
              VICIAME      29.3 +/-   8.4      29           95
              PYROASA      27.0 +/-   6.9      26           95
              RUBUPUB      26.1 +/-   5.5      21           95
              LINNBOR      22.0 +/-   7.7      35           95
              GALIBOR      18.5 +/-   4.2      23           95
              LATHVEN      11.5 +/-   9.9      86           95
              MAIACAN      10.7 +/-   2.1      19           95
              PETAPAL       8.0 +/-   1.8      23           95
              ASTECIL       7.6 +/-   1.8      24           95
```

```
                MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
              NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


----- Confidence*level(%)=95 Vegetation type=AW/ROSE Forage type=1-Grass -----

             Species    Range for con-       %      Confidence
              code      fidence level      error     level(%)

             CALACAN     74.6 +/-  29.5      40          95
             ELYMINN     19.3 +/-   5.8      30          95


---- Confidence*level(%)=95 Vegetation type=AW/ROSE Forage type=5-Litter -----

             Species    Range for con-       %      Confidence
              code      fidence level      error     level(%)

             LITTER     110.5 +/-  27.0      24          95


-- Confidence*level(%)=95 Vegetation type=AW/ROSE Forage type=4-Shrub-Twig ---

             Species    Range for con-       %      Confidence
              code      fidence level      error     level(%)

             ROSAACI     24.9 +/-   7.7      31          95
             RUBUIDA     22.1 +/-   9.0      41          95
             ALNUCRI     15.7 +/-  17.5     112          95
             POPUTRE     15.0 +/-   6.5      43          95
             CORYCOR     12.8 +/-  14.3     111          95
             VIBUEDU      6.8 +/-   4.8      70          95
             ROSAWOO      6.3 +/-   3.7      60          95
             LONIINV      6.1 +/-   3.8      62          95
             POPUBAL      5.5 +/-   5.1      94          95
             AMELALN      5.0 +/-   2.7      53          95


Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR Forage type=3-Shrub-Leaf

             Species    Range for con-       %      Confidence
              code      fidence level      error     level(%)

             ROSAACI     43.5 +/-  17.6      41          95
             VACCMYR     25.5 +/-  31.7     125          95
             ROSAWOO     17.8 +/-  18.7     105          95
             AMELALN     13.0 +/-  15.0     115          95
             SYMPALB     11.1 +/-   9.3      84          95
             SHEPCAN     10.9 +/-  17.4     159          95
             SALIBEB      7.7 +/-   7.9     103          95
             POPUTRE      7.5 +/-   8.9     119          95
             LEDUGRO      6.8 +/-  10.2     150          95
             LONIINV      6.4 +/-  12.6     197          95
```

```
              MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES
             NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS


 - Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR Forage type=2-Forb -

              Species    Range for con-      %      Confidence
               code      fidence level      error    level(%)

              ARCTUVA     97.7 +/-  82.2     84         95
              LATHOCH     91.9 +/-  20.5     22         95
              LINNBOR     83.7 +/-  24.3     29         95
              CORNCAN     63.4 +/-  20.1     32         95
              FRAGVIR     47.6 +/-  15.3     32         95
              PYROASA     27.5 +/-  13.3     48         95
              VACCCAE     24.7 +/-  11.5     47         95
              GALIBOR     20.5 +/-   7.6     37         95
              MAIACAN     13.4 +/-   4.5     34         95
              VICIAME     13.2 +/-   4.9     37         95
              RUBUPUB     11.8 +/-   6.6     56         95
              PETAPAL     10.7 +/-   5.4     51         95
              ASTECIL      9.9 +/-   3.3     34         95
              VACCVIT      7.9 +/-   7.4     93         95
              ORTHSEC      6.3 +/-   2.8     45         95
              TRIFPRA      5.6 +/-   7.0    125         95
              SOLICAN      5.1 +/-  10.7    207         95


 Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR Forage type=1-Grass

              Species    Range for con-      %      Confidence
               code      fidence level      error    level(%)

              ORYZASP    102.9 +/-  28.3     27         95
              ELYMINN     55.1 +/-  11.8     21         95
              SCHIPUR     15.9 +/-  11.5     72         95
              CARESPP      7.8 +/-   3.9     50         95
              POAPRAT      6.1 +/-   4.2     68         95


 Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR Forage type=5-Litter

              Species    Range for con-      %      Confidence
               code      fidence level      error    level(%)

              LITTER      78.4 +/-  19.0     24         95


 Confidence*level(%)=95 Vegetation type=AW/ROSE/BLUEBERR Forage type=4-Shrub-Twig

              Species    Range for con-      %      Confidence
               code      fidence level      error    level(%)

              ROSAACI     19.2 +/-  11.8     62         95
              VACCMYR     10.3 +/-  10.4    102         95
              ROSAWOO      9.6 +/-   8.4     88         95
```

# APPENDIX 5. SAS® PROGRAMS FOR DATA MANIPULATION AND ANALYSIS

## DATA INPUT AND QUALITY CHECKING ROUTINE

```
/*  THIS IS A SAS PROGRAM FOR GOING THROUGH THE ASCII FILES PRODUCED
    FOR BOTH THE EAST SLOPES AND NORTHEAST BENCHMARK PROGRAMS AND
    DETECTING COMMON ERRORS TO BE CORRECTED, SUCH AS WRONG SPECIES,
    WRONG TRANSECT TYPES ETC.  THE OUTPUT HAS BEEN DIRECTED TO
    A FILE IN THE SAME DIRECTORY AS THIS PROGRAM CALLED "WRONG.OUT" */

 OPTIONS LS=80 PS=60;
 PROC PRINTTO NEW PRINT="D:\bench98\rawdata\wrong.out" ;

 LIBNAME VEG ’d:\bench98\sasdata’;
FILENAME INDAT ’D:\BENCH98\RAWDATA\tran98_es_rev1.DAT’;
/* FILENAME INDAT ’d:\BENCH98\RAWDATA\tran98_es.DAT’;*/
data wrong;
infile INDAT ls=100 pad missover firstobs=1;
input plot $ 1-8  transect $ 10-12 DATE $ 25-30 type $ 32-34 code $ 52-58
       COVERS $ 60-79 WEIGHTS $ 81-87;
lineno=_n_ +1;
if plot=’        ’ and transect = ’   ’ and type = ’   ’ and code=’       ’
  then delete;

run;

/* TITLE ’RAW LISTING OF DATASET TRANS96.DAT’;
PROC PRINT DATA=WRONG; RUN;
TITLE; */

proc sort; by code;

data wrongsp;
merge wrong(in=inone) veg.veglst93(keep=code in=intwo); by code;
if inone and not intwo AND CODE NOTIN: (’POA SPP’ ’CARESPP’ ’LITTER’ ’SALISPP’ ’EQUISPP’ ’GENTSPP’ ’CASTSPP’
’MOSSLIC’);
run;

DATA WRONGDAT;
 SET WRONG;
 IF substr(date,1,2)<’98’;
RUN;
proc sort data=wrongdat;
 by plot;
run;

data wrongtr wrongtyp WRONGCOV ;
 set wrong;
  if transect notin: (’SL3’ ’SL4’ ’SL5’ ’SL6’ ’ST4’ ’ST5’ ’ST3’ ’ST6’ ’T3’ ’T4’ ’T5’ ’T6’) then
       output wrongtr;
  if (transect in: (’SL4’ ’SL5’ ’SL3’) AND TYPE ^=’010’) OR
     (TRANSECT IN: (’ST4’ ’ST5’ ’ST3’) AND TYPE ^=’001’) OR
     (TRANSECT IN: (’T4’ ’T5’ ’T3’) AND TYPE ^=’100’) THEN OUTPUT WRONGTYP;


CHECK=’ 0123456789’;
CHECK2=’0123456789. ’;
X=VERIFY(COVERS,CHECK);
Y=VERIFY(WEIGHTS, CHECK2);
IF X^=0 OR Y^=0 THEN OUTPUT WRONGCOV;
RUN;

PROC SORT DATA=WRONG; BY PLOT TRANSECT;
RUN;

DATA TOTPLOT;  /* CHECKS FOR PRESENCE OF ALL PLOTS AND TRANSECT TYPES */
 SET WRONG; BY PLOT TRANSECT;
IF  FIRST.TRANSECT;
RUN;

PROC SORT DATA=WRONG; BY PLOT TRANSECT CODE;

DATA DUPRECS;
 SET WRONG; BY PLOT TRANSECT CODE;
 PLOTFIRS=FIRST.PLOT; PLOTLAST=LAST.PLOT; TRANFIRS=FIRST.TRANSECT;
  TRANLAST=LAST.TRANSECT; CODEFIRS=FIRST.CODE; CODELAST=LAST.CODE;
 IF NOT FIRST.CODE;
RUN;

PROC PRINT DATA=DUPRECS; RUN;
TITLE ’RAW LIST OF DUPLICATE SPECIES FILE’;
PROC PRINT DATA=WRONGDAT;
TITLE ’WRONG DATES - MAYBE DUPLICATES FROM LAST YEAR’;
PROC PRINT DATA=WRONGSP;
TITLE ’LIST OF SPECIES TO BE CHANGED & THEIR PLOT NUMBERS’;
PROC PRINT DATA=WRONGTR;
TITLE ’LIST OF TRANSECTS THAT NEED TO BE CORRECTED & PLOT NOS’;
```

```
PROC PRINT DATA=DUPRECS;
TITLE 'LIST OF PLOT NOS. AND TRANSECTS WITH DUPLICATE SPECIES ';
PROC PRINT DATA=WRONGTYP;
TITLE 'LIST OF TRANSECTS THAT DONT MATCH TYPES, & THEIR PLOT NOS';
RUN;
PROC PRINT DATA=WRONGCOV ; VAR lineno plot CODE COVERS WEIGHTS;
TITLE 'LIST OF PLOT NOS AND POTENTIAL PROBLEM COVERS OR WEIGHTS';
RUN;
PROC PRINT DATA=TOTPLOT; VAR  PLOT TRANSECT;
TITLE 'LIST OF ALL PLOTS AND TRANSECTS WITHIN EACH PLOT IN DATASET';
TITLE2 '(ALL THAT WERE SAMPLED DURING THE SAMPLE YEAR SHOULD BE THERE)';
RUN;

 PROC PRINTTO; RUN;

TITLE;

/* compare plots and dates from last years' es plots to this year's */
libname transect 'D:\bench97\sasdata';
data esdat; set transect.esfinal; run;
proc contents data=esdat; run;


proc summary data=esdat;
where year=1997;
output out=es_sum;
class vegtype plotno transect;
run;

proc print data=es_sum;
where _type_=7;
run;


data eshead97;
 set transect.eshead97;
run;

 proc print data=eshead97;
  run;


/* get rid of the dates <98 and rewrite the text file */
 data newdata;
 infile INDAT ls=100 pad missover firstobs=1;
 input date $25-30@;
  if substr(date,1,2)>'97';

input textstr $ 1-90;
lineno=_n_ +1;


run;
data _null_;
 set newdata;
 file "c:\bench98\rawdata\tran98_es_rev1.dat";
 put @1 textstr;
run;

/* rerun the checks */

 OPTIONS LS=80 PS=60;
 PROC PRINTTO NEW PRINT="c:\bench98\rawdata\wrong.out" ;
 libname veg 'c:\bench98\sasdata';
 /* LIBNAME VEG 'd:\bench98\sasdata';*/
FILENAME INDAT 'c:\BENCH98\RAWDATA\tran98_es_rev1.DAT';
/* FILENAME INDAT 'd:\BENCH98\RAWDATA\tran98_es.DAT';*/
data wrong;
infile INDAT ls=100 pad missover firstobs=1;
input plot $ 1-8  transect $ 10-12 DATE $ 25-30 type $ 32-34 code $ 52-58
       COVERS $ 60-79 WEIGHTS $ 81-87;
lineno=_n_ +1;
if plot='        ' and transect = '   ' and type = '   ' and code='       '
  then delete;

run;


/* TITLE 'RAW LISTING OF DATASET TRANS96.DAT';
PROC PRINT DATA=WRONG; RUN;
TITLE; */

proc sort; by code;

data wrongsp;
merge wrong(in=inone) veg.veglst93(keep=code in=intwo); by code;
if inone and not intwo AND CODE NOTIN: ('POA SPP' 'CARESPP' 'LITTER' 'SALISPP' 'EQUISPP' 'GENTSPP' 'CASTSPP'
'MOSSLIC');
```

```
run;

DATA WRONGDAT;
 SET WRONG;
 IF substr(date,1,2)<'98';
RUN;
proc sort data=wrongdat;
 by plot;
run;


data wrongtr wrongtyp WRONGCOV ;
 set wrong;
  if transect notin: ( 'SL5' 'SL6'  'ST5'  'ST6'  'T5' 'T6') then
       output wrongtr;
  if (transect in: ('SL6' 'SL5' ) AND TYPE ^='010') OR
     (TRANSECT IN: ('ST6' 'ST5' ) AND TYPE ^='001') OR
     (TRANSECT IN: ('T6' 'T5' ) AND TYPE ^='100') THEN OUTPUT WRONGTYP;


CHECK=' 0123456789';
CHECK2='0123456789. ';
X=VERIFY(COVERS,CHECK);
Y=VERIFY(WEIGHTS, CHECK2);
IF X^=0 OR Y^=0 THEN OUTPUT WRONGCOV;
RUN;

PROC SORT DATA=WRONG; BY PLOT TRANSECT;
RUN;

DATA TOTPLOT;  /* CHECKS FOR PRESENCE OF ALL PLOTS AND TRANSECT TYPES */
 SET WRONG; BY PLOT TRANSECT;
IF  FIRST.TRANSECT;
RUN;

PROC SORT DATA=WRONG; BY PLOT TRANSECT CODE;

DATA DUPRECS;
 SET WRONG; BY PLOT TRANSECT CODE;
 PLOTFIRS=FIRST.PLOT; PLOTLAST=LAST.PLOT; TRANFIRS=FIRST.TRANSECT;
  TRANLAST=LAST.TRANSECT; CODEFIRS=FIRST.CODE; CODELAST=LAST.CODE;
 IF NOT FIRST.CODE;
RUN;

PROC PRINT DATA=DUPRECS; RUN;
TITLE 'RAW LIST OF DUPLICATE SPECIES FILE';
PROC PRINT DATA=WRONGDAT;
TITLE 'WRONG DATES - MAYBE DUPLICATES FROM LAST YEAR';
PROC PRINT DATA=WRONGSP;
TITLE 'LIST OF SPECIES TO BE CHANGED & THEIR PLOT NUMBERS';
PROC PRINT DATA=WRONGTR;
TITLE 'LIST OF TRANSECTS THAT NEED TO BE CORRECTED & PLOT NOS';
PROC PRINT DATA=DUPRECS;
TITLE 'LIST OF PLOT NOS. AND TRANSECTS WITH DUPLICATE SPECIES ';
PROC PRINT DATA=WRONGTYP;
TITLE 'LIST OF TRANSECTS THAT DONT MATCH TYPES, & THEIR PLOT NOS';
RUN;
PROC PRINT DATA=WRONGCOV ; VAR lineno plot CODE COVERS WEIGHTS;
TITLE 'LIST OF PLOT NOS AND POTENTIAL PROBLEM COVERS OR WEIGHTS';
RUN;
PROC PRINT DATA=TOTPLOT; VAR  PLOT TRANSECT;
TITLE 'LIST OF ALL PLOTS AND TRANSECTS WITHIN EACH PLOT IN DATASET';
TITLE2 '(ALL THAT WERE SAMPLED DURING THE SAMPLE YEAR SHOULD BE THERE)';
RUN;

 PROC PRINTTO; RUN;

TITLE;
```

# DATASET CONSTRUCTION AND FILE PREPARATION ROUTINES

```
/* This program was prepared for the Northeast Benchmark Program
   to load data captured in ASCII format from form BMTRANS according
   to the data structure defined in Appendix 2.2 of the Northeast
   Region Benchmark Program Terms of Reference (Version 4 and later) */

/* 1997 DATA INPUT PROGRAM */

   THE FILENAME DESIGNATION WILL HAVE TO BE CHANGED EACH YEAR SO THAT
   THE CURRENT YEAR’S DATA CAN BE READ IN.  IN 1993, THE FILE IS
   TRANS93.DAT, IN 1992 IT IS TRANS92.DAT, IN 1994 IT IS ... (YOU CAN FIGURE
   IT OUT).  THIS FILE CONTAINS DATA FROM BOTH THE EASTERN SLOPES AND
   NORTHEAST BENCHMARK SAMPLING NETWORKS */
LIBNAME TRAN1 ’C:\BENCH97\SASDATA’;
FILENAME TRAN2 ’c:\bench97\rawdata\tran97.dat’;
DATA FORB(DROP=SC1 SC2 SC3 T1-T9 TWIGWT LEAFWT TOTSTEM TOTTWIG
                   AVTWIG AVWT_TWG CS1 PD1-PD4 TWP LS SEC RGE MER)
     LEAF(DROP=SC1 SC2 SC3 T1-T9 TWIGWT TOTSTEM TOTTWIG
                   AVCOV AVTWIG AVWT_TWG CF1-CF10 HERBWT PD1-PD4
                   TWP LS SEC RGE MER )
     TWIG(DROP=CF1-CF10 HERBWT AVCOV CS1 LEAFWT PD1-PD4
                   TWP LS SEC RGE MER )
     HEAD(KEEP=PLOTNO TRANSECT LS SEC TWP RGE MER DATESAMP
                   FG SL ST PD1-PD4 DATEMEAS VEGTYPE YEAR BMAREA);

retain t1-t9 sc1 sc2 sc3 cf1-cf10 cs1 0 TOTSTEM TOTTWIG 0;
ATTRIB PLOTNO   FORMAT=$CHAR8.  LABEL=’PLOT NUMBER’
       TRANSECT FORMAT=$CHAR3.  LABEL=’TRANSECT NUMBER’
       LS       FORMAT=2.       LABEL=’LEGAL SUBDIV.’
       SEC      FORMAT=2.       LABEL=’SECTION’
       TWP      FORMAT=3.       LABEL=’TOWNSHIP’
       RGE      FORMAT=2.       LABEL=’RANGE’
       MER      FORMAT=1.       LABEL=’MERIDIAN’
       DATESAMP FORMAT=DATE7.   LABEL=’SAMPLE DATE’
       FG       FORMAT=1.       LABEL=’FORB/GRASS SAMPLE’
       SL       FORMAT=1.       LABEL=’SHRUB LEAF SAMPLE’
       ST       FORMAT=1.       LABEL=’TWIG SAMPLE’
       PD1      FORMAT=$CHAR2.  LABEL=’PLOT DAMAGE CODE 1’
       PD2      FORMAT=$CHAR2.  LABEL=’PLOT DAMAGE CODE 2’
       PD3      FORMAT=$CHAR2.  LABEL=’PLOT DAMAGE CODE 3’
       PD4      FORMAT=$CHAR2.  LABEL=’PLOT DAMAGE CODE 4’
       DATEMEAS FORMAT=DATE7.   LABEL=’DATE WEIGHED’
       SPECIES  FORMAT=$CHAR7.  LABEL=’SPECIES’
       CF1      FORMAT=2.       LABEL=’M/P1’
       CF2      FORMAT=2.       LABEL=’M/P2’
       CF3      FORMAT=2.       LABEL=’M/P3’
       CF4      FORMAT=2.       LABEL=’M/P4’
       CF5      FORMAT=2.       LABEL=’M/P5’
       CF6      FORMAT=2.       LABEL=’M/P6’
       CF7      FORMAT=2.       LABEL=’M/P7’
       CF8      FORMAT=2.       LABEL=’M/P8’
       CF9      FORMAT=2.       LABEL=’M/P9’
       CF10     FORMAT=2.       LABEL=’M/P10’
       AVCOV    FORMAT=2.       LABEL=’AV%COVER’
       HERBWT   FORMAT=6.1      LABEL=’DRY WT.(GM)’
       CS1      FORMAT=2.       LABEL=’FOLIAR COVER’
       LEAFWT   FORMAT=6.1      LABEL=’DRY WT.(GM)’
       SC1      FORMAT=2.       LABEL=’#STEMS’
       SC2      FORMAT=2.       LABEL=’#STEMS’
       SC3      FORMAT=4.       Label=’#TWIGS’
       T1-T7    FORMAT=2.       LABEL=’#TWIGS’
       T8       FORMAT=3.       LABEL=’#TWIGS’
       T9       FORMAT=4.       label=’#TWIGS’
       marker   format=$1.      label=’Marker for twigno >1700’
       TOTSTEM  FORMAT=4.       LABEL=’TOTAL#STEMS’
       TOTTWIG  FORMAT=4.       LABEL=’TOTAL#TWIGS’
       AVTWIG   FORMAT=3.       LABEL=’AVG#TWIGS/STEM’
       AVWT_TWG FORMAT=4.1      LABEL=’AVG.WT./TWIG(GM)’
       TWIGWT   FORMAT=6.1      LABEL=’DRY WT.(GM)’
       VEGTYPE  FORMAT=$CHAR16. LABEL=’VEG.TYPE ABBREV.’
       YEAR     FORMAT=4.       LABEL=’YEAR’
       BMAREA   FORMAT=$CHAR9.  LABEL=’BENCHMARK AREA’
       ;


INFILE TRAN2 LRECL=90  MISSOVER PAD firstobs=6;
INPUT @1 PLOTNO $CHAR8. @10 TRANSECT $CHAR3. @14 LS 2. @16 SEC 2.
             @18 TWP 3. @21 RGE 2. @23 MER 1. @25 DATESAMP YYMMDD6.
             @32 FG 1. @33 SL 1. @34 ST 1. @36 PD1 $CHAR2.
             @38 PD2 $CHAR2. @40 PD3 $CHAR2. @42 PD4 $CHAR2.
             @45 DATEMEAS YYMMDD6. @59 MARKER $1. @;
 IF PLOTNO=’        ’ THEN DELETE;
 YEAR=YEAR(DATESAMP);
 IF SUBSTR(PLOTNO,1,4)=’NEBM’ and year=1997;    /* MAKES SUBSET OF 1997 NEBM DATA */
 BMAREA=’NORTHEAST’;
/* these ’if’ statements assign each plot that will be sampled
   over the next 8 years to one of the vegetation types
```

```
   with a large enough membership for plot sampling (see Terms
   of Reference) */

IF PLOTNO IN('NEBM0016','NEBM0023','NEBM0033','NEBM0048','NEBM0052',
             'NEBM0054','NEBM0064','NEBM0065','NEBM0067','NEBM0069'
             'ESBM0001' 'ESBM0002' 'ESBM0006' 'ESBM0030' 'ESBM0037'
             'ESBM0049' 'ESBM0060' 'ESBM0061' 'ESBM0062' 'ESBM0026' )
          THEN VEGTYPE='AW/ROSE';


IF PLOTNO IN('NEBM0010','NEBM0019','NEBM0025','NEBM0026','NEBM0038',
             'NEBM0039','NEBM0044','NEBM0055','NEBM0060','NEBM0072')
          THEN VEGTYPE='AW/HAZEL';

IF PLOTNO IN('NEBM0017','NEBM0020','NEBM0027','NEBM0030','NEBM0031',
             'NEBM0035','NEBM0036','NEBM0037','NEBM0073','NEBM0075')
          THEN VEGTYPE='AW/HAZEL/PEA';

IF PLOTNO IN('NEBM0014' 'NEBM0051' 'NEBM0040' 'NEBM0032' 'NEBM0076'
              'NEBM0077')        THEN VEGTYPE='AW/ROSE/BLUEBERRY';

IF PLOTNO IN('ESBM0003' 'ESBM0019' 'ESBM0046' 'ESBM0048' 'ESBM0053')
          THEN VEGTYPE='PB-AW/HONEYSUCKLE';

IF PLOTNO IN('ESBM0012' 'ESBM0014' 'ESBM0020' 'ESBM0032' 'ESBM0033'
             'ESBM0036' 'ESBM0038' 'ESBM0039' 'ESBM0047' 'ESBM0054')
          THEN VEGTYPE='AW/ALDER';

OUTPUT HEAD;


/* These statements check for the occurrence of one and only one
   'true' value for the type of sample. Depending on the type,
    the input record is read in the required columns and variable
    values are input according to informat specs.  If there is more
    than one '1' for FG (Forb/grass type), SL (Shrub leaf type) or
    ST (Shrub twig type), if there are no ones, or if there are
    missing values for the other two instead of 0's, an error
    message will be printed to log and the observation won't be output.
    (If this becomes a problem, will have to use the transect type
     and substr function to read the type)
   */

  IF (FG=1 AND SL=0 AND ST=0) AND SUBSTR(PLOTNO,1,4)='NEBM' THEN DO;
     INPUT   @52 SPECIES $CHAR7. @60 (CF1-CF10) (2.) @81 HERBWT 6.1;
     AVCOV=SUM(OF CF1-CF10)/10;
     BMAREA='NORTHEAST';
     OUTPUT FORB;
  END;

ELSE IF (FG=0 AND SL=1 AND ST=0) AND SUBSTR(PLOTNO,1,4)='NEBM' THEN DO;
     INPUT   @52 SPECIES $CHAR7. @60 CS1 2. @81 LEAFWT 6.1;
     OUTPUT LEAF;
     BMAREA='NORTHEAST';
  END;

ELSE IF (FG=0 AND SL=0 AND ST=1) AND SUBSTR(PLOTNO,1,4)='NEBM'
     AND MARKER=' ' THEN DO;

     INPUT @52 SPECIES $CHAR7. @60 (SC1 SC2 T1-T7) (2.) T8 3. @81 TWIGWT 6.1;
     TOTSTEM=SUM(OF SC1-SC2);
     TOTTWIG=SUM(OF T1-T8);
     AVTWIG=TOTTWIG/TOTSTEM;
     AVWT_TWG=TWIGWT/TOTTWIG;
     T9=0;
     SC3=0;
     BMAREA='NORTHEAST';
     OUTPUT TWIG;
  END;

ELSE IF (FG=0 AND SL=0 AND ST=1) AND SUBSTR(PLOTNO,1,4)='NEBM'
     AND MARKER='*' THEN DO;
     INPUT @52 SPECIES $CHAR7. @60 SC3 4. T9 4. @81 TWIGWT 6.1;
     TOTSTEM=SC3;
     TOTTWIG=T9;
     T1=0; T2=0; T3=0; T4=0; T5=0; T6=0; T7=0; T8=0; SC1=0; SC2=0;
     AVTWIG=TOTTWIG/TOTSTEM;
     AVWT_TWG=TWIGWT/TOTTWIG;
     BMAREA='NORTHEAST';
     OUTPUT TWIG;
  END;

 WINDOW PROBLEM IROW=1 ICOLUMN=1
 #5 @5 'YOU HAVE EITHER INDICATED MORE THAN ONE SAMPLE TYPE'
 #6 @5 'OR YOU HAVE NOT ENTERED ZERO VALUES FOR THE ALTERNATE'
 #7 @5 'SAMPLE TYPES.  THE FIRST OCCURRENCE OF THIS SITUATION IS:'
#10 @5 'PLOT NUMBER: ' PLOTNO $CHAR8.   PROTECT=YES
#11 @5 'TRANSECT   : ' TRANSECT $CHAR3. PROTECT=YES
```

```
#12 @5 'CLIP DATE  : ' DATESAMP DATE7.  PROTECT=YES
#13 @5 'LINE OF ASCII FILE: ' _N_ 4.    PROTECT=YES
#14 @5 'YOU MUST EDIT YOUR DATASET STARTING WITH THE ABOVECAPTIONED'
#15 @5 'PLOT: THE PROGRAM WILL NOT READ THE REMAINDER OF VALUES'
#16 @5 'UNTIL YOU DO. TRY RUNNING THE PROGRAM DATATEST.SAS TO CHECK VALUES'
#18 @10 'PRESS ENTER TO RETURN TO THE SAS DISPLAY MANAGER, THEN'
#19 @10 'EDIT THE ASCII FILE.';

ELSE IF NOT((FG=1 AND SL=0 AND ST=0) AND (FG=0 AND SL=1 AND ST=0) AND
     (FG=0 AND SL=0 AND ST=1)) THEN  DO;
     DISPLAY PROBLEM ;
     STOP;
     END;
RUN;



/* The next step sorts the temporary datafile HEAD, removes duplicate
   observations, and writes the result to a permanent datafile with
   libref tran1.   YOU MUST CHANGE THE PERMANENT DATASET DESIGNATION TO
   REFLECT THE CURRENT YEAR EG TRAN1.NEHEAD92 BECOMES TRAN1.NEHEAD93 IN
   1993, TRAN1.NEHEAD94 IN 1994 ETC */

 PROC SORT DATA=HEAD NODUPKEY OUT=TRAN1.NEHEAD97(RENAME=(DATESAMP=DATE1 DATEMEAS=DATE2));
   BY YEAR PLOTNO TRANSECT FG SL ST;

 PROC SORT DATA=FORB ;
   BY YEAR PLOTNO TRANSECT FG SL ST;

 PROC SORT DATA=LEAF;
   BY YEAR PLOTNO TRANSECT FG SL ST;

 PROC SORT DATA=TWIG;
   BY YEAR PLOTNO TRANSECT FG SL ST;
 RUN;

/* The next steps allow the user to:
    -edit the header information, which is then merged with each of
     the temporary vegetation databases.  The header-related information
     for each observation in each of these databases is then updated
     automatically, and the fields are protected so that changes can't
     be made to the header info except through the header file.  If
     changes are made to the header file, it will be necessary to run
     the subsequent data steps (with sorting) in order to make
     changes to the vegetation datasets */

 DATA _NULL_;
 WINDOW READ_ME
 #1 @5 'FOUR SAS DATASETS HAVE BEEN CREATED IN THE PRECEDING INPUT'
 #2 @5 'PROGRAM: 1) A HEADER DATASET 2)A FORB DATASET CONTAINING'
 #3 @5 'COVER+WT VALUES FOR HERBS 3)A LEAF DATASET CONTAINING COVER+'
 #4 @5 'WT VALUES FOR SHRUB LEAF BIOMASS 4)A TWIG DATASET (COV, WT)'

 #6 @5 'THE NEXT FOUR STEPS IN THE PROGRAM ALLOW YOU TO EDIT'
 #7 @5 'EACH OF THE FOUR DATASETS THAT HAVE BEEN CREATED.  '
 #8 @5 'THE FIRST DATASET IS THE HEADER INFORMATION (PLOT NUMBER, '
 #9 @5 'TRANSECT NUMBER, SAMPLE DATE ETC.  YOU SHOULD ENSURE THAT'
 #10 @5 'THESE VALUES ARE CORRECT, IN PARTICULAR THE SAMPLE DATE.'
 #11 @5 'THEY WILL BE DISPLAYED IN THEIR CORRECTED FORM IN THE'
 #12 @5 'FOLLOWING THREE DATASETS THAT YOU CAN EDIT, BUT YOU WILL'
 #13 @5 'NOT BE ABLE TO CHANGE THEIR VALUES. ALSO, IF THESE VALUES'
 #14 @5 'WERE INCORRECT IN THE INITIAL ASCII FILE YOU READ IN, THEY'
 #15 @5 'WILL BE CHANGED BACK TO INCORRECT VALUES IN THE SAS DATA'
 #16 @5 'SET IF YOU RUN THE ENTIRE DATA INPUT PROGRAM AGAIN WITHOUT'
 #17 @5 'CHANGING THE ASCII FILE.'
 #20 @5 'PRESS ENTER TO BEGIN EDITING';

 DISPLAY READ_ME;
 STOP;
 RUN;

/* !!!!! WARNING !!!!!  YOU MUST CHANGE THE PERMANENT DATASET DESIGNATION
   TO MATCH THE YEAR OF SAMPLING, SO FOR 1993, THE FOLLOWING "DATA="
   STATEMENT WOULD HAVE TO READ "DATA=TRAN1.NEHEAD93" AND SO ON */

proc fsedit data=TRAN1.NEHEAD97 screen=TRAN1.header;
informat DATE1   DATE2      date7. ;
run;

PROC SORT DATA=TRAN1.NEHEAD97;
 BY YEAR PLOTNO TRANSECT FG SL ST;

DATA TRAN1.NEFORB97;
MERGE FORB(DROP=DATESAMP DATEMEAS) TRAN1.NEHEAD97; BY YEAR PLOTNO TRANSECT FG SL ST;
DROP LS SEC TWP RGE MER FG SL ST PD1 PD2 PD3 PD4 MARKER;
 RENAME DATE1=DATESAMP DATE2=DATEMEAS;
 IF FG=1;   /* this statement keeps only forb/grass observations */
 RUN;
```

```
DATA TRAN1.NELEAF97;
 MERGE LEAF(DROP=DATESAMP DATEMEAS) TRAN1.NEHEAD97; BY YEAR PLOTNO TRANSECT FG SL ST;
DROP LS SEC TWP RGE MER FG SL ST PD1 PD2 PD3 PD4 MARKER;
 RENAME DATE1=DATESAMP DATE2=DATEMEAS;
 IF SL=1; /* keep only shrub leaf biomass & cover observations */
 RUN;

DATA TRAN1.NETWIG97;
 MERGE TWIG(DROP=DATESAMP DATEMEAS) TRAN1.NEHEAD97; BY YEAR PLOTNO TRANSECT FG SL ST;
DROP LS SEC TWP RGE MER FG SL ST PD1 PD2 PD3 PD4;
 RENAME DATE1=DATESAMP DATE2=DATEMEAS;
 IF ST=1; /* keep only twig counts and twig biomass observations */
 RUN;



/* THE NEXT STEPS APPEND DATA FROM THESE EDITED DATASETS TO A MASTER DATA
   SET CONTAINING DATA FROM MULTIPLE YEARS.  IT IS IMPORTANT TO ENSURE
   THAT DATA RECORDS ARE NOT DUPLICATED IN THE PROCESS, THEREFORE EACH
   DATASET IS FIRST SORTED BY KEY VARIABLES AND THEN DUPLICATE RECORDS
   ARE WRITTEN TO A TEXT FILE FOR CHECKING.  THE VALID VALUES CAN THEN
   BE EDITED USING THE FSEDIT PROCEDURE, AND THE INVALID VALUES DELETED.
   IT IS IMPORTANT TO CHANGE THE "DATA" DESIGNATION IN THE APPEND
   PROCEDURE TO REFLECT THE CURRENT YEAR EG TRAN1.NEHEAD92 BECOMES
   TRAN1.NEHEAD93 IN 1993, TRAN1.NEHEAD94 IN 1994 ETC. */


PROC APPEND BASE=TRAN1.NE_HEAD DATA=TRAN1.NEHEAD97;
RUN;

PROC APPEND BASE=TRAN1.NE_FORB DATA=TRAN1.NEFORB97;
RUN;

PROC APPEND BASE=TRAN1.NE_LEAF DATA=TRAN1.NELEAF97;
RUN;

PROC APPEND BASE=TRAN1.NE_TWIG DATA=TRAN1.NETWIG97;
RUN;

PROC SORT DATA=TRAN1.NE_HEAD NODUPKEY;
 BY YEAR PLOTNO TRANSECT FG SL ST;
RUN;

PROC SORT DATA=TRAN1.NE_FORB nodupkey;
 BY YEAR PLOTNO TRANSECT SPECIES herbwt;

PROC SORT DATA=TRAN1.NE_LEAF nodupkey;
 BY YEAR PLOTNO TRANSECT SPECIES leafwt;

PROC SORT DATA=TRAN1.NE_TWIG nodupkey;
 BY YEAR PLOTNO TRANSECT SPECIES twigwt;
 RUN;


/* ------------------------------------------------------------- */

  /* PROGRAM TO DETECT DUPLICATE FORB SPECIES AND OUTPUT THEM TO
   A FILE FOR EDITING.  */
FILENAME DUPL 'C:\BENCH97\RAWDATA\DUPLFORB.OUT';
DATA _NULL_ ; SET TRAN1.NE_FORB END=LAST;
                BY YEAR PLOTNO TRANSECT SPECIES;
   WINDOW PROBLEM IROW=1 ICOLUMN=1
   #5 @5 'YOU MAY HAVE LOADED A DATASET WITH MORE THAN ONE WEIGHT VALUE'
   #6 @5 'FOR A GIVEN YEAR, PLOT NUMBER, TRANSECT AND SPECIES.'
  #7 @5 'A LIST OF DUPLICATE VALUES, IF ANY, IS WRITTEN TO FILE "DUPLFORB." '
  #8 @5 'PRESS ENTER TO RETURN TO THE SAS PROGRAM MANAGER WINDOW, THEN'
  #9 @5 'REVIEW THIS FILE AND EDIT.'
  #11 @5 ' IF YOU DO HAVE DUPLICATE WEIGHT VALUES, THEN YOU WILL HAVE TO'
  #12 @5 ' EDIT THE MASTER DATASET "TRAN1.NE_FORB" USING THE FSEDIT'
  #13 @5 ' PROCEDURE AND THE TEXT FILE "DUPLFORB.OUT" TO SELECT THE'
  #14 @5 ' VALID VALUE AND DELETE THE INVALID ONE ';

 IF LAST THEN DO;   DISPLAY PROBLEM;
       STOP;
       END;

 IF NOT FIRST.SPECIES OR NOT LAST.SPECIES;
DATE=DATETIME();
FILE DUPL HEADER=NEWPAGE LINESLEFT=L MOD PRINT;

   PUT PLOTNO=$8. YEAR=4. TRANSECT=$3. SPECIES=$CHAR7. HERBWT=6.1;
   IF L<2 THEN PUT _PAGE_;
 RETURN;
 NEWPAGE:
 PUT @5 'DUPLICATE WEIGHT VALUES IN THE DATASET TRAN1.NE_FORB'/
     @8 'FOR A SPECIES IN A GIVEN PLOT/TRANSECT/YEAR'/
     @14 'REPORT GENERATED ON DATE AND TIME:  ' DATE DATETIME15.//
```

```
 @2 'EDIT THE DATASET TRAN1.NE_FORB USING THE FSEDIT PROCEDURE'/
 @2 'AND DELETE THE OBSERVATION(S) HAVING INCORRECT HERBWT VALUES'//;
 RETURN;
RUN;


  /* PROGRAM TO DETECT DUPLICATE 'SHRUB-LEAF' SPECIES AND OUTPUT THEM TO
   A FILE FOR EDITING.  */
FILENAME DUPL 'C:\BENCH97\RAWDATA\DUPLLEAF.OUT';
DATA _NULL_ ; SET TRAN1.NE_LEAF END=LAST;
                BY YEAR PLOTNO TRANSECT SPECIES;
   WINDOW PROBLEM IROW=1 ICOLUMN=1
   #5 @5 'YOU MAY HAVE LOADED A DATASET WITH MORE THAN ONE WEIGHT VALUE'
   #6 @5 'FOR A GIVEN YEAR, PLOT NUMBER, TRANSECT AND SPECIES.'
  #7 @5 'A LIST OF DUPLICATE VALUES, IF ANY, IS WRITTEN TO FILE "DUPLLEAF." '
  #8 @5 'PRESS ENTER TO RETURN TO THE SAS PROGRAM MANAGER WINDOW, THEN'
  #9 @5 'REVIEW THIS FILE AND EDIT.'
  #11 @5 ' IF YOU DO HAVE DUPLICATE WEIGHT VALUES, THEN YOU WILL HAVE TO'
  #12 @5 ' EDIT THE MASTER DATASET "TRAN1.NE_LEAF" USING THE FSEDIT'
  #13 @5 ' PROCEDURE AND THE TEXT FILE "DUPLLEAF.OUT" TO SELECT THE'
  #14 @5 ' VALID VALUE AND DELETE THE INVALID ONE ';

 IF LAST THEN DO;   DISPLAY PROBLEM;
       STOP;
       END;

 IF NOT FIRST.SPECIES OR NOT LAST.SPECIES;
DATE=DATETIME();
FILE DUPL HEADER=NEWPAGE LINESLEFT=L MOD PRINT;
   PUT PLOTNO=$8. YEAR=4. TRANSECT=$3. SPECIES=$CHAR7. LEAFWT=6.1;
   IF L<2 THEN PUT _PAGE_;
 RETURN;
 NEWPAGE:
 PUT @5 'DUPLICATE WEIGHT VALUES IN THE DATASET TRAN1.NE_LEAF'/
     @8 'FOR A SPECIES IN A GIVEN PLOT/TRANSECT/YEAR'/
     @14 'REPORT GENERATED ON DATE AND TIME:  ' DATE DATETIME15.//
 @2 'EDIT THE DATASET TRAN1.NE_LEAF USING THE FSEDIT PROCEDURE'/
 @2 'AND DELETE THE OBSERVATION(S) HAVING INCORRECT LEAFWT VALUES'//;
 RETURN;
RUN;


  /* PROGRAM TO DETECT DUPLICATE 'SHRUB-TWIG' SPECIES AND OUTPUT THEM TO
   A FILE FOR EDITING.  */
FILENAME DUPL 'C:\BENCH97\RAWDATA\DUPLTWIG.OUT';
DATA _NULL_ ; SET TRAN1.NE_TWIG END=LAST;
                BY YEAR PLOTNO TRANSECT SPECIES;
   WINDOW PROBLEM IROW=1 ICOLUMN=1
   #5 @5 'YOU MAY HAVE LOADED A DATASET WITH MORE THAN ONE WEIGHT VALUE'
   #6 @5 'FOR A GIVEN YEAR, PLOT NUMBER, TRANSECT AND SPECIES.'
  #7 @5 'A LIST OF DUPLICATE VALUES, IF ANY, IS WRITTEN TO FILE "DUPLTWIG." '
  #8 @5 'PRESS ENTER TO RETURN TO THE SAS PROGRAM MANAGER WINDOW, THEN'
  #9 @5 'REVIEW THIS FILE AND EDIT.'
  #11 @5 ' IF YOU DO HAVE DUPLICATE WEIGHT VALUES, THEN YOU WILL HAVE TO'
  #12 @5 ' EDIT THE MASTER DATASET "TRAN1.NE_TWIG" USING THE FSEDIT'
  #13 @5 ' PROCEDURE AND THE TEXT FILE "DUPLTWIG.OUT" TO SELECT THE'
  #14 @5 ' VALID VALUE AND DELETE THE INVALID ONE ';
 IF LAST THEN DO;   DISPLAY PROBLEM;
       STOP;
       END;

 IF NOT FIRST.SPECIES OR NOT LAST.SPECIES;
DATE=DATETIME();
FILE DUPL HEADER=NEWPAGE LINESLEFT=L MOD PRINT;

   PUT PLOTNO=$8. YEAR=4. TRANSECT=$3. SPECIES=$CHAR7. TWIGWT=6.1;
   IF L<2 THEN PUT _PAGE_;
 RETURN;
 NEWPAGE:
 PUT @5 'DUPLICATE WEIGHT VALUES IN THE DATASET TRAN1.NE_TWIG'/
     @8 'FOR A SPECIES IN A GIVEN PLOT/TRANSECT/YEAR'/
     @14 'REPORT GENERATED ON DATE AND TIME:  ' DATE DATETIME15.//
 @2 'EDIT THE DATASET TRAN1.NE_TWIG USING THE FSEDIT PROCEDURE'/
 @2 'AND DELETE THE OBSERVATION(S) HAVING INCORRECT TWIGWT VALUES'//;
 RETURN;
RUN;
```

# TABLE CONSTRUCTION ROUTINES

```
/* This program was originally written for Northeast
     Benchmark Program (Resource Information Branch program
     NE-004-92) in 1992 by Dave Downing for the first set of 10
     sample plots, and was subsequently modified in 1993 to allow
     analyses of more than one vegetation type over a number of
     years for both the Northeast and Eastern Slopes.  The time
     to run this program in 1993 on a Toshiba t3300sl laptop with
     4mb RAM and a 386sl chip (no math coprocessor) was about 40
     minutes.

   This version produces tables and graphs that summarize the
   contribution of individual species and species groups to forage
   productivity.  The species groups are grasses, forbs and shrubs;
   each species group is further divided into quality classes (good,
   fair and poor) according to criteria provided by Gerry Ehlert in
   1991 for the Boreal Mixedwood   */


/*   THIS IS THE VERSION RUN IN MARCH 1998 ON 1997  DATA */





/* --------------------------------------------------------------*/
              /* DEFINE LIBRARIES FOR DATA AND FORMATS */

LIBNAME TRAN1 ’c:\BENCH97\SASDATA’;
libname library ’C:\BENCH96\SASDATA’;

/* --------------------------------------------------------------*/
              /* DEFINE FORMATS FOR USE IN PROGRAM */

PROC FORMAT LIBRARY=library;
 VALUE $QUALITY ’1’=’1-Good’
                ’2’=’2-Fair’
                ’3’=’3-Poor’;

 VALUE $RESPONS ’1’=’Decreaser’
                ’2’=’Increaser’
                ’3’=’Invader’;

 VALUE $LAYCODE ’G’=’1-Grass’
                ’C’=’2-Forb’
                ’B’=’3-Shrub-Leaf’
                ’X’=’4-Shrub-Twig’
                ’T’=’5-Litter’;

 VALUE $vegtype ’AW/ROSE’=’Aspen/rose/forb,  ’
                ’AW/HAZEL’=’Aspen/hazelnut/sarsaparilla,  ’
                ’AW/HAZEL/PEA’= ’Aspen/hazelnut/peavine,  ’
                ’AW/ROSE/BLUEBERR’=’Aspen/rose/blueberry,  ’
                ’AW/ALDER’=’Aspen/alder,  ’
                ’PB-AW/HONEYSUCKL’=’Balsam poplar-aspen/honeysuckle,  ’
 ;

RUN;

/* -------------------------------------------------------------- */
      /* CREATE WORKING DATASETS FROM THE MASTER DATASET.
         THESE ARE LOST WHEN YOU EXIT THE SAS SYSTEM */

DATA FORB1(KEEP=PLOTNO VEGTYPE TRANSECT SPECIES AVCOV HERBWT YEAR);
  SET TRAN1.NE_forb;
spec=left(species);           /*these statements are included in the */
 species=put(spec, $char7.);  /*event that species arent left justified */
 drop spec;                   /*(species with leading blanks*/
 RUN;                         /*are treated as different species) */

DATA LEAF1(KEEP=PLOTNO VEGTYPE TRANSECT SPECIES CS1 LEAFWT YEAR);
  SET TRAN1.NE_leaf;
spec=left(species);
 species=put(spec, $char7.);
 drop spec;
RUN;

DATA TWIG1(KEEP=PLOTNO VEGTYPE TRANSECT SPECIES TOTSTEM TOTTWIG AVWT_TWG
           TWIGWT YEAR);
  SET TRAN1.NE_twig;
spec=left(species);
 species=put(spec, $char7.);
```

```
 drop spec;
RUN;


PROC SORT DATA=FORB1; BY PLOTNO SPECIES TRANSECT YEAR;
RUN;
PROC SORT DATA=LEAF1; BY PLOTNO SPECIES TRANSECT YEAR;
RUN;
PROC SORT DATA=TWIG1; BY PLOTNO SPECIES TRANSECT YEAR;

DATA ALLTRAN;
 MERGE FORB1 LEAF1 TWIG1;
  BY PLOTNO SPECIES TRANSECT YEAR;

/* When these datasets are merged, a number of missing values
   are created by the merge (e.g. there is no leafwt variable
   in the forb dataset).  Therefore, a 'biomass' variable
   is created that sums all of the other weight variables */

 BIOMASS=SUM(HERBWT,LEAFWT,TWIGWT);
 LABEL BIOMASS='Total dry wt(gm.)';
RUN;
 /* -----------------------------------------------------------------*/
             /* DATASTEPS TO PRODUCE REQUIRED MATRIX
                OF ALL SPECIES-ALL PLOTS-ALL VALID TRANSECTS */



    /* The next series of data steps and sort procs is necessary
       so that the correct mean value can be calculated for each
       species in a given vegetation type.  Proc TABULATE takes the
       total sum of dry weight values and divides by the number of
       times a species occurs (i.e.  as a non-missing value).
       Without these steps, the mean reported value of a species
       that occurs for example just once in ten plots will be much
       higher than its true average value across the whole set of
       10 plots (e.g.  LATHVEN occurs in one of 10 plots with a dry
       weight of 67g; PROC TABULATE reports its average weight as
       67g.  Therefore, a way has to be found of 'marking' the occur-
       rence of LATHVEN as a zero value for all those plots in which
       it does not occur (9 of 10 plots) and therefore come up with
       the correct average, over 10 plots, of 6.7g (67g/10plots).

     This part of the program produces complete matrices of values for
     variables.  It is complex and  rather long because of the need
     to account for changes in species and biomass values throughout
     a sampling period at a number of plots belonging to groups, where
     each group is started in a different year.
      If you want to compile averages, standard deviations etc from
     this data over all years together, you have to create a full
     matrix which includes:

       1.  All of the species which occur in all of the vegetation
           types over all of the years, so that you can track
           differences in species between as well as within vegetation
           types through the years (some of the less common species
           might show up in one or two out of five years of sampling,
           but should be listed anyway).


       2.  All of the transects in which each species occurs, in all
          of the vegetation types over all of the years, so you can
          track changes in type of forage produced (twig, leaf,
          forb/grass) within and between vegetation types.  You need
          to include only valid transect-species combinations i.e.  if
          you start collecting vegetation data from plots belonging to
          a vegetation type starting in 1993, you shouldn't have a
          bunch of blank records in the database for the year 1992,
          otherwise you will throw off your calculations of mean,
          standard dev.  etc.  over the actual period of data
          collection.  The remark above about less-common species applies
          here also, with the additional criterion of what transect
          type they occur in (e.g. one year species C might occur in
          transect SL1 and ST1, the next year it might occur in
          transect SL2 only, but to get an average over the two years
          you need to have a nonmissing value for transects SL1, SL2,
          ST1 and ST2 (SAS procedures calculate avgs from nonmissing
          values only)).


   The steps involved are:
      - create a list of plots and vegetation types;
      - cross this list with a list of species and transects;
        (this produces the matrix)
      - read the actual data values back into the matrix using
        a merge process
 */
```

```
 PROC SORT DATA=ALLTRAN; BY SPECIES;

 DATA SPECIES (KEEP=transect species); /*DATASET WITH SPECIES, TRANSECTS*/
  SET ALLTRAN;
   BY SPECIES;
   IF FIRST.SPECIES THEN DO;
  /* THE NEXT STATEMENTS READ THE FIRST ONE OR TWO CHARACTERS OF
     THE TRANSECT AND THEN CREATE ALL POSSIBLE COMBINATIONS OF
     TRANSECT NUMBERS (MIGHT NEED TO INCREASE TO MORE THAN T7 BY ADDING
     NEW OUTPUT STATEMENTS IF SAMPLING OCCURS OVER MORE THAN 7 YEARS */

   transect='T1'; output;
   transect='T2'; output;
   transect='T3'; output;
   transect='T4'; output;
   transect='T5'; output;
   transect='T6'; output;
   transect='T7'; output;
   transect='SL1'; OUTPUT;
   TRANSECT='SL2'; OUTPUT;
   TRANSECT='SL3'; OUTPUT;
   TRANSECT='SL4'; OUTPUT;
   TRANSECT='SL5'; OUTPUT;
   TRANSECT='SL6'; OUTPUT;
   TRANSECT='SL7'; OUTPUT;
   TRANSECT='ST1'; OUTPUT;
   TRANSECT='ST2'; OUTPUT;
   TRANSECT='ST3'; OUTPUT;
   TRANSECT='ST4'; OUTPUT;
   TRANSECT='ST5'; OUTPUT;
   TRANSECT='ST6'; OUTPUT;
   TRANSECT='ST7'; OUTPUT;
  END;
 RUN;


 /* NEXT STEP GETS RID OF DUPLICATE SPECIES-TRANSECT COMBINATIONS
    USING THE NODUPKEY OPTION IN THE SORT PROC */

 PROC SORT DATA=SPECIES NODUPKEY; BY SPECIES TRANSECT;
 title 'data set species';
RUN;

 PROC SORT DATA=ALLTRAN; BY PLOTNO YEAR;
 RUN;

 DATA PLOT (KEEP=PLOTNO YEAR VEGTYPE);
 SET ALLTRAN;                          /* DATASET WITH JUST PLOTS */
   BY PLOTNO YEAR;                     /* ORDERED BY YEAR (EACH PLOT */
    IF FIRST.YEAR;                     /* IS UNIQUE FOR EACH YEAR */

 OUTPUT;
  RUN;

 DATA MATRIX;
 SET PLOT; by plotno YEAR;
 /* EVERY PLOT AND YEAR COMBINATION IS UNIQUE*/

 DO J=1 TO nobs;
 /* FOR EVERY UNIQUE PLOT AND YEAR COMBINATION, SET THE SPECIES
    FILE FROM BEGINNING TO END SO THAT THERE IS A FULL SET OF
    SPECIES AND TRANSECTS ASSOCIATED WITH EVERY UNIQUE PLOT
    AND YEAR COMBINATION.  THIS TECHNIQUE IS CALLED 'CROSSING' */

  SET SPECIES POINT=J nobs=nobs;
 /* SET COVER AND BIOMASS VALUES TO ZERO EVERY TIME A SPECIES RECORD
    IS READ IN */

 BIOMASS=0; HERBWT=0; AVCOV=0; CS1=0; AVWT_TWG=0; TOTSTEM=0; TOTTWIG=0;
 TWIGWT=0; LEAFWT=0;
 /* CF1-CF10=0; */   /* optional-retain all cover values- not needed */

 /* THE SELECT STATEMENTS ONLY OUTPUT THOSE TRANSECTS FROM THE
    DATASET THAT ARE SUPPOSED TO BE THERE.  FOR EXAMPLE,
    THE VEGTYPE 'AW/HAZEL' WASN'T COLLECTED IN 1992 SO SHOULD NOT BE
    IN THE DATASET, AND SUBSEQUENTLY THE RIGHT TRANSECT DESIGNATION
    HAS TO BE CHOSEN FOR THE YEAR OF SAMPLING.  THE VEGTYPE 'AW/ROSE',
    WHICH WAS FIRST SAMPLED IN 1992, HAS TRANSECTS STARTING T1,SL1 AND
    ST1 IN THAT YEAR, WITH T2,ST2, AND SL2 IN 1993 AND SO ON.  VEGTYPE
    'AW/HAZEL' WAS FIRST SAMPLED IN 1993 AND HAS TRANSECTS STARTING T1,SL1
    AND ST1 IN 1993, WITH T2,ST2, AND SL2 IN 1994 AND SO ON. IF MORE
    VEGETATION TYPES ARE ADDED IN FUTURE, THESE SELECT STATEMENTS WILL
    HAVE TO BE MODIFIED TO ACCOUNT FOR THESE.  IN 1994, THE ASPEN -BLUEBERRY
    TYPE WAS ADDED. */

  SELECT (VEGTYPE);
   WHEN ('AW/ROSE') DO;
```

```
 SELECT (YEAR);
  WHEN (1992) DO;  /*SAMPLING STARTED FOR THIS TYPE IN '92 */
   IF TRANSECT IN('T1' 'SL1' 'ST1') THEN OUTPUT;
   END;
  WHEN (1993) DO;
   IF TRANSECT IN('T2' 'ST2' 'SL2') THEN OUTPUT;
   END;
  WHEN (1994) DO;
   IF TRANSECT IN('T3' 'ST3' 'SL3') THEN OUTPUT;
   END;
  WHEN (1995) DO;
   IF TRANSECT IN('T4' 'ST4' 'SL4') THEN OUTPUT;
   END;
  WHEN (1996) DO;
   IF TRANSECT IN('T5' 'ST5' 'SL5') THEN OUTPUT;
   END;
  WHEN (1997) DO;
   IF TRANSECT IN('T6' 'ST6' 'SL6') THEN OUTPUT;
   END;
  WHEN (1998) DO;
   IF TRANSECT IN('T7' 'ST7' 'SL7') THEN OUTPUT;
   END;
 OTHERWISE;
END; /* END 'SELECT YEAR' BLOCK */
END; /* END 'WHEN 'AW/ROSE' BLOCK */
WHEN ('AW/HAZEL') DO;
 SELECT (YEAR);
  WHEN (1992) DO; /* NO DATA COLLECTED FOR THIS TYPE IN 1992 */
                  /* SO ALL TRANSECTS HAVE TO BE DELETED FOR THAT YEAR */
   IF TRANSECT IN('T1' 'T2' 'T3' 'T4' 'T5' 'T6' 'T7'
                  'SL1' 'SL2' 'SL3' 'SL4' 'SL5' 'SL6' 'SL7'
                  'ST1' 'ST2' 'ST3' 'ST4' 'ST5' 'ST6' 'ST7')
      THEN DELETE;
   END;
  WHEN (1993) DO;
   IF TRANSECT IN('T1' 'SL1' 'ST1') THEN OUTPUT;
   END;
  WHEN (1994) DO;
   IF TRANSECT IN('T2' 'ST2' 'SL2') THEN OUTPUT;
   END;
  WHEN (1995) DO;
   IF TRANSECT IN('T3' 'ST3' 'SL3') THEN OUTPUT;
   END;
  WHEN (1996) DO;
   IF TRANSECT IN('T4' 'ST4' 'SL4') THEN OUTPUT;
   END;
  WHEN (1997) DO;
   IF TRANSECT IN('T5' 'ST5' 'SL5') THEN OUTPUT;
   END;
  WHEN (1998) DO;
   IF TRANSECT IN('T6' 'ST6' 'SL6') THEN OUTPUT;
   END;

  OTHERWISE;
END; /*END 'SELECT YEAR' BLOCK */
END; /*END 'WHEN AW/HAZEL' BLOCK */

 WHEN ('AW/ROSE/BLUEBERR') DO;
 SELECT (YEAR);
  WHEN (1992) DO; /* NO DATA COLLECTED FOR THIS TYPE IN 1992 */
                  /* SO ALL TRANSECTS HAVE TO BE DELETED FOR THAT YEAR */
   IF TRANSECT IN('T1' 'T2' 'T3' 'T4' 'T5' 'T6' 'T7'
                  'SL1' 'SL2' 'SL3' 'SL4' 'SL5' 'SL6' 'SL7'
                  'ST1' 'ST2' 'ST3' 'ST4' 'ST5' 'ST6' 'ST7')
      THEN DELETE;
   END;
  WHEN (1993) DO; /* NO DATA COLLECTED FOR THIS TYPE IN 1993 */
                  /* SO ALL TRANSECTS HAVE TO BE DELETED FOR THAT YEAR */
   IF TRANSECT IN('T1' 'T2' 'T3' 'T4' 'T5' 'T6' 'T7'
                  'SL1' 'SL2' 'SL3' 'SL4' 'SL5' 'SL6' 'SL7'
                  'ST1' 'ST2' 'ST3' 'ST4' 'ST5' 'ST6' 'ST7')
      THEN DELETE;
   END;
  WHEN (1994) DO;
   IF TRANSECT IN('T1' 'ST1' 'SL1') THEN OUTPUT;
   END;
  WHEN (1995) DO;
   IF TRANSECT IN('T2' 'ST2' 'SL2') THEN OUTPUT;
   END;
  WHEN (1996) DO;
   IF TRANSECT IN('T3' 'ST3' 'SL3') THEN OUTPUT;
   END;
  WHEN (1997) DO;
   IF TRANSECT IN('T4' 'ST4' 'SL4') THEN OUTPUT;
   END;
  WHEN (1998) DO;
   IF TRANSECT IN('T5' 'ST5' 'SL5') THEN OUTPUT;
   END;
```

```
     OTHERWISE;
   END; /*END 'SELECT YEAR' BLOCK */
   END; /*END 'WHEN AW/ROSE/BLUEBERRY' BLOCK */
  OTHERWISE;
  END; /*END SELECT VEGTYPE BLOCK */

 END;  /* END DO LOOP */
 RUN;


 /* GET BOTH THE 'EMPTY' MATRIX AND THE ORIGINAL DATASET 'ALLTRAN'
    IN THE SAME SORTED ORDER SO THEY CAN BE MERGED */

 PROC SORT DATA=MATRIX; BY PLOTNO SPECIES TRANSECT YEAR;
 title 'data set MATRIX with all species cover set to 0';

 PROC SORT DATA=ALLTRAN; BY PLOTNO SPECIES TRANSECT YEAR;


/*UPDATE STATEMENT GETS AROUND THE PROBLEM OF MISSING BIOMASS VALUES AND
  CONSEQUENTLY SCREWY ADDITIONS WHEN THE COMBINE FILE IS CREATED BELOW */

 DATA BIOMASS;
 UPDATE MATRIX ALLTRAN; BY PLOTNO SPECIES TRANSECT YEAR;
 RUN;



/* ----------------------------------------------------------------*/
      /* DATASTEPS THAT ASSIGN LAYERS TO SPECIES, DEPENDING ON
         THE TRANSECTS THEY OCCUR IN AS WELL AS THEIR CLASSIFICATION
         IN A MASTER DATASET REFERENCED AS TRAN1.VEGLST93 */

PROC SORT DATA=BIOMASS;
BY SPECIES TRANSECT YEAR;
RUN;

PROC SORT DATA=TRAN1.VEGLST93(KEEP=CODE FORM_LAY RENAME=(CODE=SPECIES))
 OUT=VEGLST NODUPKEY; BY SPECIES;
RUN;

DATA COMBINE;
MERGE VEGLST BIOMASS;
      BY SPECIES;
LABEL FORM_LAY='Forage type';
IF FORM_LAY='A' THEN FORM_LAY='B';
IF BIOMASS=. THEN DELETE;  /* Gets rid of lookup table species not in plots *

/* The species list 'TRAN1.VEGLST93' does not include codes that recognize
   the occurrence of a genus without a named species (e.g. Carex spp.).
   The following statement was included to account for these and
   will need to be reviewed annually as there are sure to be a few
   additions each year.

*/
/* THE NEXT IF STATEMENT WAS PUT IN TO TAKE CARE OF THE CASES WHERE
   THE SPECIES 'LITTER' IS RIGHT-JUSTIFIED IN THE INPUT DATABASE.
   IN THESE CASES, THE SORT PROGRAMS PULL THE RIGHT JUSTIFIED WORD
   (HAVING A LEADING BLANK) OUT BEFORE THE LEFT-JUSTIFIED WORD, BE-
   CAUSE BLANKS ARE FIRST IN THE ASCII COLLATING SEQUENCE */

IF SPECIES='LITTER ' THEN FORM_LAY='T';


 IF SPECIES='CARESPP' OR SPECIES='CAREXSP' THEN FORM_LAY='G';
 IF SPECIES='POA SP ' OR SPECIES='POA SPP' THEN FORM_LAY='G';
 IF SPECIES='POA PRA' or SPECIES='POAPRAT' then form_lay='G';
 IF SPECIES='POAPRAT' THEN FORM_LAY='G';
 IF SPECIES='CAREPRT' THEN FORM_LAY='G';
 IF SPECIES='ROSASPP'  OR SPECIES='ROSA SP' THEN FORM_LAY='B';
 IF SPECIES='BROMSPP' OR SPECIES='BROM SP' THEN FORM_LAY='G';
 IF SPECIES='AGROSPP' OR SPECIES='AGRO SP' THEN FORM_LAY='G';
 IF SPECIES='SALISPP' OR SPECIES='SALI SP' THEN FORM_LAY='B';
 IF SPECIES='EQUISPP' OR SPECIES='EQUI SP' THEN FORM_LAY='C';
 IF SPECIES='GENTSPP'  OR SPECIES='CASTSPP' THEN FORM_LAY='C';


 IF SPECIES=:LEFT('MOSS') OR SPECIES=:LEFT('LICHEN') THEN FORM_LAY='C';
/* This list includes those species which are categorized as forbs for
   sampling purposes, even though they are technically shrubs because
   of woody above-ground structures (yes, even bunchberry).
*/

IF SPECIES IN ('LINNBOR' 'ARCTUVA' 'ARCTRUB'
               'EMPENIG' 'GAULHIS' 'KALMPOL' 'LOISPRO'
               'LUETPEC' 'LYCOANN' 'LYCOCOM' 'LYCOALP'
               'LYCOCLA' 'LYCOINU' 'LYCOSIT' 'OXYCMIC'
```

```
               'OXYCQUA' 'PENSALB' 'PENSALI' 'PENSCON'
               'PENSELL' 'PENSERI' 'PENSFRU' 'PENSGRA'
               'PENSLYA' 'PENSNIT' 'PENSPRO' 'POLYAMP'
               'RUBUARC' 'RUBUCHA' 'RUBUPED' 'RUBUPUB'
               'SALIARC' 'SALIRET' 'SOLANIG' 'SOLATRI'
               'VACCCAE' 'VACCMYT' 'VACCSCO' 'VACCVIT'
               'CORNCAN') THEN FORM_LAY='C';

/* THIS STATEMENT ACCOUNTS FOR A CODING ERROR MADE FOR POLYGALA SENEGA, WHICH IS
   RECORDED AS POLYSEG IN THE SPECIES LIST BUT AS POLYSEN ON MOST OF THE FIELD
   FORMS */

IF SPECIES='POLYSEN' THEN DO;
 SPECIES='POLYSEG';
  FORM_LAY='C';
 END;

/* THIS STATEMENT ACCOUNTS FOR THE DIFFERENCE BETWEEN THE 'B'
   LAYER (SHRUB-LEAF PRODUCTIVITY) AND THE 'X' LAYER (SHRUB-TWIG
   PRODUCTIVITY)*/

IF TRANSECT IN('ST1' 'ST2' 'ST3' 'ST4' 'ST5' 'ST6' 'ST7')
   AND FORM_LAY='B' THEN DO;
     FORM_LAY='X';
     END;
      IF FORM_LAY='X' AND TRANSECT IN('T1' 'T2' 'T3' 'T4' 'T5'
                      'T6' 'T7') THEN DO;
        FORM_LAY='B';
      END;

/*  EARLIER IN THE PROGRAM, WE CREATED A FULL SPECIES-TRANSECT MATRIX WHERE
    EVERY SPECIES WAS MATCHED TO EVERY POSSIBLE TRANSECT.  THIS DOES NOT REFLECT
    REALITY, BECAUSE FORBS, GRASSES,MOSSES, LICHENS AND LITTER ARE NOT EVALUATED
    IN TWIG (ST) OR LEAF (SL) TRANSECTS.  THE NEXT STEP GETS RID OF THESE */

IF FORM_LAY IN ('C' 'G' 'T') THEN IF TRANSECT NOTIN('T1' 'T2' 'T3' 'T4' 'T5'
                                                     'T6' 'T7') THEN DELETE;

RUN;

PROC SORT DATA=COMBINE; BY SPECIES TRANSECT;
RUN;

/* ----------------------------------------------------------- */

/* This step reads in a small datafile that summarizes the known
   values for forage quality and grazing response as given by
   Gerry Ehlert in 1991. The first two lines of this file give
   information on the file contents therefore the infile statement
   starts with line 3 ('FIRSTOBS=3').
*/


FILENAME FORAGE 'c:\BENCH97\RAWDATA\FORAGVAL.DAT';

DATA FORAGVAL;
INFILE FORAGE LRECL=20 FIRSTOBS=3;
INPUT @1 SPECIES $CHAR7. @8 GRAZRESP $1. @9 FORAGVAL $1.;
LABEL GRAZRESP='Grazing response' FORAGVAL='Forage value';
RUN;

PROC SORT DATA=FORAGVAL;
  BY SPECIES ;   run;

/* ------------------------------------------------------------ */

DATA TRAN1.NEFINAL;
  MERGE foragval combine ; BY SPECIES;
  IF BIOMASS=. THEN DELETE; /* this delete statement gets rid of species
                              in the dataset 'FORAGVAL' that aren't in
                              any of the plots */
 /* The next two statements assign a value of 'fair' to each species
    that was not assigned a value in the previous datastep (i.e. not
    in Ehlert's list)
 */

  IF GRAZRESP=' ' THEN GRAZRESP='2';
  IF FORAGVAL=' ' THEN FORAGVAL='2';
  IF SPECIES='LITTER' THEN FORAGVAL='3';

/* 'Common' values are calculated from the dry weight values */

 KG_HA=2000*(BIOMASS/1000);
 LB_AC=0.892*KG_HA;
LABEL KG_HA='kg/ha' LB_AC='lbs/ac';

run;
```

```
/* ------------------------------------------------------------------*/

/* The following three steps create a subset of the dataset
     TRAN1.NEFINAL that contains information on the total dry weight
     of each of 1) the three quality classes 2) the five layers
     3)five different combinations of class data:  good quality
     grasses, good quality forbs, fair quality grasses, fair
     quality forbs, poor quality forbs (there are no poor quality
     grasses to date), good,fair, and poor quality shrubs (leaf
     biomass) and good,fair and poor quality shrubs (twig
     biomass).  This step reads in the dataset created in the
     previous step, adds all of the various dry weight measures
     together for each layer (forb or grass) for each category of
     quality, and outputs observations to various datasets.  */


PROC SORT DATA=TRAN1.NEFINAL; BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY;
RUN;


DATA NSUMFOR;  /*subset of data where totals for each layer belonging */
              /*to a particular vegetation type in a given year      */
              /*are calculated for each plot in the type             */

DO I=1 TO NUMOBS;
 SET TRAN1.NEFINAL(KEEP=PLOTNO FORAGVAL lb_ac kg_ha biomass FORM_LAY YEAR
             VEGTYPE) NOBS=NUMOBS;
/* NOBS option defines # of DO loop iterations */
  BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY ;
 TOTLB+LB_AC;
 TOTKG+KG_HA;
 TOTGM+BIOMASS;
   IF LAST.form_lay THEN DO; OUTPUT;
     TOTLB=0.0;   /* Reset variables to 0 for next iteration */
     TOTKG=0.0;
     TOTGM=0.0;
    END;
 END;

LABEL TOTGM='Total wt(gm)' TOTKG='Total wt(kg/ha)'
      TOTLB='Total wt(lb/ac)';
RUN;

PROC SORT DATA=TRAN1.NEFINAL OUT=NSUMFORQ; BY  vegtype year PLOTNO FORAGVAL;
PROC SORT DATA=TRAN1.NEFINAL OUT=NSUMFORL; BY  vegtype year PLOTNO FORM_LAY;


 /*Step creates dataset with totals by forage quality only */
DATA NTOTFOR (keep=gtotlb gtotkg gtotgm year
             lb_ac kg_ha foragval biomass plotno vegtype species);
DO I=1 TO NUMOBS;
 SET NSUMFORQ NOBS=NUMOBS; /* NOBS option defines # of DO loop iterations */
  BY vegtype year PLOTNO FORAGVAL ;
 GTOTLB+LB_AC;
 GTOTKG+KG_HA;
 GTOTGM+BIOMASS;
   IF LAST.foragval     THEN DO; OUTPUT;
     GTOTLB=0.0;   /* Reset variables to 0 for next iteration */
     GTOTKG=0.0;
     GTOTGM=0.0;
    END;
 END;

LABEL GTOTGM='Total wt(gm)'         GTOTKG='Total wt(kg/ha)'
      GTOTLB='Total wt(lb/ac)';
RUN;

 /* Step creates dataset with totals by layer for each plot within
    a vegetation type during a given year                          */

 DATA NTOTLAY (keep= ltotlb ltotkg ltotgm year
                    lb_ac kg_ha form_lay biomass plotno vegtype species);
 DO I=1 TO NUMOBS;
  SET NSUMFORL NOBS=NUMOBS; /* NOBS option defines # of DO loop iterations */
   BY vegtype year PLOTNO FORM_LAY;
  LTOTLB+LB_AC;
  LTOTKG+KG_HA;
  LTOTGM+HERBWT;
    IF LAST.form_lay THEN DO; OUTPUT;
      LTOTLB=0.0;   /* Reset variables to 0 for next iteration */
      LTOTKG=0.0;
      LTOTGM=0.0;
     END;
  END;

 LABEL LTOTGM='Total wt(gm)'         LTOTKG='Total wt(kg/ha)'
       LTOTLB='Total wt(lb/ac)';
 RUN;
```

```
/* --------------------------------------------------------------- */
   /*  The following steps create a dataset 'SHORTLST' which
      can be used with PROC TABULATE to produce a summary
      of individual plots for a given year.              */

/* This set of data steps sums up all of the species that
   usually occur with low weights (<=5 lb/ac), all of the species
   that probably occur with higher weights (>5 lb/ac), and then puts
   them together.  This is a way of reducing the amount
   of paper output from PROC TABULATE, which will generate
   4 or 5 pages of output for each plot in each year, or
   around 150 pages for 1992/93 in the Northeast region alone */


/* The first datastep produces a subset with species occurring @ <5lb/ac
   in any plot in any year, and assigns them a new species name
   based on their forage value   */

data otherspp;
LENGTH SPECIES $10.;
set tran1.nefinal(where=(lb_ac <=5.00 AND FORM_LAY NE 'T')
 keep=lb_ac kg_ha biomass species plotno transect form_lay
       vegtype year foragval );

 IF FORAGVAL='1' THEN species='OTHER-GOOD';
 IF FORAGVAL='2' THEN SPECIES='OTHER-FAIR';
 IF FORAGVAL='3' THEN SPECIES='OTHER-POOR';
RUN;


PROC SORT DATA=OTHERSPP; BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY;
RUN;

/*this datastep sums all of the weight values (lb_ac only) for
  each layer.  The total of species that occur within each layer and
  that all have the same forage quality is output to the dataset
  othersp2 */

DATA OTHERSP2; SET OTHERSPP(RENAME=(LB_AC=LB KG_HA=KG BIOMASS=B));
   BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY;
LB_AC+LB;
KG_HA+KG;
BIOMASS+B;
IF LAST.FORM_LAY THEN DO;
 OUTPUT;
 LB_AC=0.0;
 KG_HA=0.0;
 BIOMASS=0.0;
END;
DROP KG B LB;
RUN;

/* this datastep produces a dataset that includes all of the
 most common species (listed in the WHERE statement).  One
 little problem:  the species called 'OTHERSP-GOOD' (or
 OTHERSP-FAIR or OTHERSP-POOR) contains the sum of all values
 under 5lb/ac, which may include one or more of the species
 in the list.  E.g.  ORTHSEC might occur (and often does
 occur) with less than 5 lb/ac in a plot, so its
 corresponding 'summary' species 'OTHERSP-P' will contain its
 value too.  Therefore, it is necessary to DELETE, from each
 record, those observations having species other than the
 ones prefixed 'OTHERSP-' from the dataset OR assign those
 species a lb/ac value of 0.0.  If you do the former (delete)
 you end up with an incomplete matrix of species values (some
 will be assigned as missing values in PROC TABULATE) and the
 corresponding calculation of averages will be done using the
 actual number of plots in which the species occurred as the
 denominator.  If you do the latter, you maintain the proper
 denominator, but your calculated average is less than the
 true average for those species, because you've converted
 positive values to zero values in acknowledging they're a
 part of the 'OTHERSP-' group.  The best course of action is
 probably to DELETE these species and use the dataset 'SHORTLST'
 only for generating tables for each plot in a given year. */

 DATA MAINSPP;
LENGTH SPECIES $ 10.;
SET TRAN1.NEFINAL (KEEP=LB_AC VEGTYPE YEAR TRANSECT FORM_LAY FORAGVAL PLOTNO SPECIES
  WHERE=(SPECIES IN( 'ACHIMIL   '  'ACTARUB   ' 'AGROTRA   '
                    'ALLICER   '  'ALNUCRI   ' 'AMELALN   '
                    'ANEMCAN   '  'APOCAND   ' 'ARALNUD   '
                    'ASTECIL   '  'ASTECON   ' 'ASTRAME   '
                    'BETUPAP   '  'CALACAN   ' 'CAREPRT   '
                    'CARESPP   '  'CAREXSP   ' 'CORNCAN   '
                    'CORNSTO   '  'CORYCOR   ' 'DISPTRA   '
                    'ELYMINN   '  'EPILANG   ' 'FRAGVIR   '
```

```
                    ’GALIBOR   ’  ’GALITRI   ’ ’HERALAN   ’
                    ’HIERUMB   ’  ’LATHOCH   ’ ’LATHVEN   ’
                    ’LINNBOR   ’  ’LITTER    ’ ’LONIDIO   ’
                    ’LONIINV   ’  ’MAIACAN   ’ ’MERTPAN   ’
                    ’MITENUD   ’  ’ORTHSEC   ’ ’ORYZASP   ’
                    ’PETAPAL   ’  ’POA SPP   ’ ’POACOMP   ’
                    ’POPUBAL   ’  ’POPUTRE   ’ ’PRUNPEN   ’
                    ’PRUNVIR   ’  ’PYROASA   ’ ’PYROELL   ’
                    ’RIBEOXY   ’  ’RIBETRI   ’ ’ROSAACI   ’
                    ’ROSASPP   ’  ’ROSAWOO   ’ ’RUBUIDA   ’
                    ’RUBUPUB   ’  ’SALIBEB   ’ ’SANIMAR   ’
                    ’SCHIPUR   ’  ’SHEPCAN   ’ ’SOLICAN   ’
                    ’SYMPALB   ’  ’TARAOFF   ’ ’THALVEN   ’
                    ’TRIFREP   ’  ’VACCCAE   ’ ’VACCMYR   ’
                    ’VIBUEDU   ’  ’VICIAME   ’ ’VIOLCAN   ’ )));
IF FORM_LAY=’B’ AND SUBSTR(TRANSECT,1,1)=’T’ THEN DELETE;
if LB_ac<=5.00 and species notin (’OTHER-GOOD’ ’OTHER-FAIR’ ’OTHER-POOR’)
  THEN DELETE;
RUN;

PROC SORT DATA=MAINSPP;BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY;

/* This step interleaves the dataset with OTHERSP- and the dataset
   with species having lb_ac >5.00 .  Use this if you’re printing
   summary tables for plots by year, but NOT if you’re trying to
   get summaries of multi-year records for vegetation types or
   year-by year summaries of vegetation types, otherwise you
   will have erroneous calculations of averages and other statistics */


DATA SHORTLST;
LENGTH SPECIES $ 10.;
 SET MAINSPP OTHERSP2; BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY;
 RUN;

libname library ’c:\veg\benchmrk\sasfiles\newfile’;
/* -------------------------------------------------------------*/

/* This step produces tables that summarize values by forage quality
   type and layer, and by species, layer, quality type and plot number.
*/
LIBNAME LIBRARY ’C:\BENCH97\SASDATA’;
/* This step produces tables that summarize values by forage quality
   type and layer, and by species, layer, quality type and plot number.
*/
PROC PRINTTO NEW PRINT=’C:\BENCH97\SASOUT\TABNE97.OUT’;
OPTIONS PAGESIZE=55 LINESIZE=100 FORMCHAR=',ƒ„…†‡ˆ‰Š‹Œ+=|-/\<>*'
  NODATE PAGENO=1;
/* Table summarizing quality only */
PROC TABULATE DATA=NTOTFOR FORMAT=10.1 order=formatted;

 CLASS vegtype FORAGVAL YEAR;
 VAR GTOTLB ;
  TABLE  VEGTYPE,                                  /*page dimension*/
   Year='Summary for year'*(FORAGVAL) foragval='Summary for all years'*all=' ' , /*column dimension*/
   GTOTLB='Total wt. (lb/ac)'*(SUM N MEAN STDERR PCTSUM<FORAGVAL ALL>)/BOX=_PAGE_; /*row dimension*/
 FORMAT FORAGVAL $QUALITY. vegtype $vegtype. ;
 KEYLABEL SUM='Total wt.' MEAN='Avg.wt (lb/ac)' PCTSUM='Percent of total'
         N='Total # plots'   STDERR='Standard error';

TITLE1 'PLOT DATA FOR NORTHEAST BENCHMARK VEGETATION TYPES';
TITLE2 'SUMMARIZED OVER ALL PLOTS ACCORDING TO FORAGE QUALITY*';
footnote '* Forage quality as defined by Ehlert(1991, unpublished)';
RUN;
TITLE; FOOTNOTE;

/* Table summarizing layer only */
 PROC TABULATE DATA=NTOTLAY format=10.1 order=formatted;
 CLASS vegtype year FORM_LAY PLOTNO;
 VAR LTOTLB ;
 TABLE VEGTYPE,     /*page dimension*/
    year='Summary for year'*(FORM_LAY) form_lay='Summary for all years'*all=' ',  /*column dimension */
     LTOTLB='Total wt. (lb/ac)'*(SUM N MEAN STDERR PCTSUM<FORM_LAY ALL>)/BOX=_PAGE_; /*row dimension*/
 KEYLABEL SUM='Total wt.' MEAN='Avg.wt (lb/ac)' PCTSUM='Percent of total'
         N='Total # plots'   STDERR='Standard error';
 FORMAT FORM_LAY $LAYCODE. vegtype $vegtype. ;
TITLE1 'PLOT DATA FOR NORTHEAST BENCHMARK PROGRAM VEGETATION TYPES';
TITLE2 'SUMMARIZED OVER ALL PLOTS ACCORDING TO FORAGE TYPE';
RUN;
TITLE; FOOTNOTE;

/* Tables summarizing quality and layer */
 PROC TABULATE DATA=NSUMFOR format=10.1 order=formatted;
 CLASS FORAGVAL  FORM_LAY VEGTYPE YEAR;
 VAR TOTLB ;
  TABLE VEGTYPE,  /* page dimension*/
     year='Summary for year'*(FORM_LAY*FORAGVAL)
        form_lay='Summary over all years'*foragval='of layer and quality'*all=' ',   /*column dimension*/
```

```
     TOTLB=’Total wt. (lb/ac)’*(SUM N MEAN STDERR PCTSUM<FORM_LAY*FORAGVAL ALL> )/BOX=_PAGE_;/*row dimension*/
 KEYLABEL SUM=’Total wt.’ MEAN=’Avg.wt (lb/ac)’ PCTSUM=’Percent of total’
         N=’Total # plots’   STDERR=’Standard error’;
 format vegtype $vegtype. form_lay $laycode. foragval $quality.;
TITLE1 ’PLOT DATA FOR NORTHEAST BENCHMARK PROGRAM VEGETATION TYPES’;
TITLE2 ’SUMMARIZED OVER ALL PLOTS ACCORDING TO FORAGE TYPE AND QUALITY*’;
footnote ’* Forage quality as defined by Ehlert(1991, unpublished)’;

/*These next table statements generate numerous pages of output on
  each plot - not necessary for most readers, so they’re commented out
  here */

 /* PROC TABULATE DATA=SHORTLST FORMAT=10.1 order=formatted;
  CLASS VEGTYPE PLOTNO SPECIES FORAGVAL FORM_LAY YEAR;
  VAR LB_AC;
  TABLE VEGTYPE YEAR*PLOTNO, SPECIES*FORAGVAL*FORM_LAY ALL, LB_AC*(SUM PCTSUM
  <PLOTNO*SPECIES*FORAGVAL*FORM_LAY ALL>)/BOX=_PAGE_;
 FORMAT vegtype $vegtype. FORAGVAL $QUALITY. FORM_LAY $LAYCODE.;
KEYLABEL SUM=’Total wt.’ MEAN=’Avg.wt (lb/ac)’ PCTSUM=’Percent of total’
              STDERR=’Standard error’;
RUN;
TITLE; FOOTNOTE;
*/


OPTIONS PAGESIZE=55 LINESIZE=100 FORMCHAR= ',ƒ„…†‡ˆ‰Š‹Œ+=|-/\<>*'
  NODATE ;
/* Tables summarizing species contributions over all plots */
PROC TABULATE DATA=TRAN1.NEFINAL(keep=year species plotno foragval
     vegtype form_lay lb_ac transect ) format=10.1 order=formatted;
 where not(FORM_lay=:'B' and transect=:'T');
/* This WHERE statement is necessary to get rid of those observations
   where the layer is 'shrub-leaf' and the transect is T1-T7.  Cover
   data were collected for shrubs occurring along the grass-forb transect,
   but including these observations effectively doubles the denominator
   and makes the calculation of averages incorrect */

 CLASS vegtype YEAR SPECIES PLOTNO FORAGVAL FORM_LAY;
 VAR LB_AC;
  TABLE vegtype*(YEAR all='ALL YEARS'), /*page dimension*/
           SPECIES*FORAGVAL*FORM_LAY ALL=' ', /*row dimension */
   LB_AC*(SUM N MEAN STDERR PCTSUM <SPECIES*FORAGVAL*FORM_LAY ALL>)
            /BOX=_PAGE_;   /*page dimension*/
 FORMAT vegtype $vegtype. FORAGVAL $QUALITY. FORM_LAY $LAYCODE.;
KEYLABEL SUM='Total wt.' MEAN='Avg.wt (lb/ac)' PCTSUM='Percent of total'
           N='Total # of plots'   STDERR='Standard error' ;

TITLE1 'VEGETATION TYPE TABLES FOR NORTHEAST BENCHMARK PROGRAM';
TITLE2 'SUMMARIZED BY VEGETATION TYPE AND YEAR FOR ALL SPECIES*';
footnote '* Forage quality as defined by Ehlert(1991, unpublished)';RUN;
TITLE;
FOOTNOTE;
PROC PRINTTO; RUN;
```

## GRAPH PREPARATION ROUTINES

```
/*  NORTHEAST BENCHMARK GRAPH PROGRAM */
 /* VERSION FOR DATA COLLECTED IN 1996 and processed in 1997 AND RUN UNDER SAS VERSION 6.11 */

 libname tran1 'c:\bench97\sasdata';


/* This program takes data from the master dataset, summarizes
   it according to vegetation type, layer and species, and
   then produces a set of graphs for (each vegetation type by
   year and for all years) by forage type (grass, forb, shrub-leaf
   etc)  which are stored in a catalog for future replay */

 PROC SUMMARY DATA=TRAN1.NEFINAL MAXDEC=1 mean stderr n;
  WHERE NOT(TRANSECT=:'T' AND FORM_LAY='B');
  /* the WHERE statement gets rid of observations in the master
     dataset that cause averages to be wrongly computed (i.e.
     all of the weights are zero for shrubs that were noted as
     to cover in the microplots on the forb/grass transects */


  CLASS YEAR FORM_LAY foragval SPECIES;
 VAR LB_AC;
  OUTPUT OUT=SUMMARY mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

/* The following three steps create a subset of the dataset
     TRAN.NEFINAL that contains information on the total dry weight
     of each of 1) the three quality classes 2) the five layers
     3)five different combinations of class data:  good quality
     grasses, good quality forbs, fair quality grasses, fair
     quality forbs, poor quality forbs (there are no poor quality
     grasses to date), good,fair, and poor quality shrubs (leaf
     biomass) and good,fair and poor quality shrubs (twig
     biomass).  This step reads in the dataset created in the
     previous step, adds all of the various dry weight measures
     together for each layer (forb or grass) for each category of
     quality, and outputs observations to various datasets.  */


PROC SORT DATA=TRAN1.NEFINAL; BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY;
RUN;


DATA NSUMFOR;  /*subset of data where totals for each layer belonging */
              /*to a particular vegetation type in a given year      */
              /*are calculated for each plot in the type             */

DO I=1 TO NUMOBS;
 SET TRAN1.NEFINAL(KEEP=PLOTNO FORAGVAL lb_ac kg_ha biomass FORM_LAY YEAR
             VEGTYPE) NOBS=NUMOBS;
/* NOBS option defines # of DO loop iterations */
  BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY ;
 TOTLB+LB_AC;
 TOTKG+KG_HA;
 TOTGM+BIOMASS;
   IF LAST.form_lay THEN DO; OUTPUT;
     TOTLB=0.0;   /* Reset variables to 0 for next iteration */
     TOTKG=0.0;
     TOTGM=0.0;
    END;
 END;

LABEL TOTGM='Total wt(gm)' TOTKG='Total wt(kg/ha)'
      TOTLB='Total wt(lb/ac)';
RUN;

PROC SORT DATA=TRAN1.NEFINAL OUT=NSUMFORQ; BY  vegtype year PLOTNO FORAGVAL;
PROC SORT DATA=TRAN1.NEFINAL OUT=NSUMFORL; BY  vegtype year PLOTNO FORM_LAY;


 /*Step creates dataset with totals by forage quality only */
DATA NTOTFOR (keep=gtotlb gtotkg gtotgm year
             lb_ac kg_ha foragval biomass plotno vegtype species);
DO I=1 TO NUMOBS;
 SET NSUMFORQ NOBS=NUMOBS; /* NOBS option defines # of DO loop iterations */
  BY vegtype year PLOTNO FORAGVAL ;
 GTOTLB+LB_AC;
 GTOTKG+KG_HA;
 GTOTGM+BIOMASS;
   IF LAST.foragval      THEN DO; OUTPUT;
     GTOTLB=0.0;   /* Reset variables to 0 for next iteration */
     GTOTKG=0.0;
     GTOTGM=0.0;
    END;
 END;
```

```
LABEL GTOTGM='Total wt(gm)'         GTOTKG='Total wt(kg/ha)'
      GTOTLB='Total wt(lb/ac)';
RUN;

 /* Step creates dataset with totals by layer for each plot within
    a vegetation type during a given year                          */

 DATA NTOTLAY (keep= ltotlb ltotkg ltotgm year
                    lb_ac kg_ha form_lay biomass plotno vegtype species);
 DO I=1 TO NUMOBS;
  SET NSUMFORL NOBS=NUMOBS; /* NOBS option defines # of DO loop iterations */
   BY vegtype year PLOTNO FORM_LAY;
  LTOTLB+LB_AC;
  LTOTKG+KG_HA;
  LTOTGM+HERBWT;
    IF LAST.form_lay THEN DO; OUTPUT;
      LTOTLB=0.0;   /* Reset variables to 0 for next iteration */
      LTOTKG=0.0;
      LTOTGM=0.0;
     END;
  END;

 LABEL LTOTGM='Total wt(gm)'         LTOTKG='Total wt(kg/ha)'
       LTOTLB='Total wt(lb/ac)';
 RUN;

/* -------------------------------------------------------------- */
/* OUTPUT OF DATA BY VEGETATION TYPE, YEAR AND FORAGE LAYER         */
 libname library 'c:\bench96\sasdata';

PROC FORMAT LIBRARY=LIBRARY;
  VALUE YEARbnch 1992='1992, '
             1993='1993, '
             1994='1994, '
             1995='1995, '
             1996='1996, '
             1997='1997, '
             1998='1998, '
             1999='1999, '
               .= 'ALL YEARS, '
;
VALUE $vegtype 'AW/ROSE'='Aspen/Rose/Forb,  '
               'AW/HAZEL'='Aspen/hazelnut/sarsaparilla,  '
               'AW/HAZEL/PEA'= 'Aspen/Hazelnut/Peavine,  '
               'AW/ROSE/BLUEBERRY'='Aspen/rose/blueberry,  '
               'AW/ALDER'='Aspen/alder,  '
               'PB-AW/HONEYSUCKL'='Balsam poplar-Aspen/honeysuckle,  '
;
VALUE $LAYER  'B'='Shrub-Leaf'
              'C'='Forb'
              'G'='Grass'
              'T'='Litter'
              'X'='Shrub-Twig'
;
 RUN;


 PROC SORT DATA=summary out=graph; BY VEGTYPE YEAR FORM_LAY; RUN;

title1 f=duplex h=1.2 c=black box=1 j=c 'NORTHEAST REGION BENCHMARK PROGRAM';
TITLE2 F=duplex H=1.2 c=black
 j=c   'Summary of average dry wt.(lb/ac) by species and type of forage';
title3 F=duplex H=1.2 j=c u=1 c=black
       'for each vegetation type in the year specified';
title5 ' ';

FOOTNOTE1 F=DUPLEX H=0.9 C=BLACK J=L '*  Vegetation type codes: AW/ROSE = Aspen/Rose/Forb/Reedgrass  AW/HAZEL=
Aspen/Hazelnut/Sarsaparil
la';
FOOTNOTE2 F=DUPLEX H=0.9 C=BLACK J=C  '   AW/ROSE/BLUEBERR = Aspen/Rose/Blueberry';
pattern1 v=x2 c=red;
pattern2 v=x2 c=green;
pattern3 v=x2 c=blue;
axis2  value=(rotate=0 FONT=simplex HEIGHT=0.8) label=('Plant species') ;
legend2  frame across=1 VALUE=(H=1) label=('Forage value' H=1);


goptions norotate cback=white ctext=black device=win TARGETDEVICE=WINPRTM
  HTEXT=0.8 FTEXT=swiss fby=simplex HBY=0.9;



      DM  'PGM; LOG' LOG;
      PROC GCHART  DATA=GRAPH
      GOUT=tran1.neGRAPH;
      WHERE _TYPE_ IN (7,15) AND lb_ac>2.0;
      hBAR SPECIES / mean
      TYPE=mean  SUMVAR=lb_ac legend=legend2 maxis=axis2 nozeros
```

```
        GROUP=FORAGVAL DESCENDING patternid=group;
      BY VEGTYPE YEAR FORM_LAY;
        label vegtype='Vegetation type*'
              form_lay='Forage type'
              lb_ac='Average lbs/ac'
              year= 'Year';
 FORMAT  FORAGVAL $QUALITY. FORM_LAY $LAYER.
        year yearbnch. lb_ac 5.1;
RUN;

*********************************************************************


/* -------------------------------------------------------------------*/
/* PROGRAM TO PRODUCE SUMMARY GRAPHS FROM BENCHMARK CLIP DATA - THESE
   GRAPHS SUMMARIZE FORAGE AND BROWSE ACCORDING TO QUALITY WITHIN
   THE TYPE OF FORAGE (GRASS, FORB, ETC).
   */
 PROC SUMMARY DATA=nSUMFOR MAXDEC=1 mean stderr n;
  CLASS YEAR FORM_LAY foragval;
 VAR TOTLB;
  OUTPUT OUT=nSUMFOR2 mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

PROC SORT DATA=nSUMFOR2; BY VEGTYPE YEAR; RUN;

title1 f=duplex h=1.0 c=black box=1 j=c 'NORTHEAST REGION REGION BENCHMARK PROGRAM';
TITLE2 F=duplex H=1.0 c=black
 j=c   'Summary of average dry wt.(lb/ac) by forage type and forage value';
title3 F=duplex H=1.0 j=c u=1 c=black
       'for each vegetation type in the year specified';
title5 ' ';
pattern1 v=S c=red;
pattern2 v=X2 c=green;
pattern3 v=L1 c=blue;
pattern4 v=s c=brown;
pattern5 v=e c=black;
axis1 length=35 pct;
axis2 length=50 pct  value=none label=none ;
legend2  frame across=1 VALUE=(H=1) label=('Forage value' H=0.9);



goptions norotate cback=white ctext=black device=win
  HTEXT=1.0 FTEXT=SWISS  FBY=SIMPLEX HBY=0.9;



      PROC GCHART  DATA=NSUMFOR2
      GOUT=tran1.NEGRAPH;
      WHERE _TYPE_ IN (3 7);
      BY VEGTYPE YEAR;
      hBAR foragval / mean  coutline=black space=1
      TYPE=mean  SUMVAR=LB_AC legend=legend2 raxis=axis1 maxis=axis2
      group=form_lay subgroup=foragval DESCENDING patternid=subgroup nozeros;
      FORMAT form_lay $laycode. foragval $quality. YEAR yearbnch. VEGTYPE $VEGTYPE.;
      label form_lay='Forage type'     YEAR= 'Year'
            VEGTYPE='Vegetation type'
            lb_ac='Average lbs/ac';
      RUN;



/* -------------------------------------------------------------------*/
/* PROGRAM TO PRODUCE SUMMARY GRAPHS FROM BENCHMARK CLIP DATA - THESE
   GRAPHS SUMMARIZE FORAGE AND BROWSE ACCORDING TO FORAGE VALUE       */



 PROC SUMMARY DATA=NTOTFOR MAXDEC=1 mean stderr n;
  CLASS YEAR foragval;
 VAR GTOTLB;
  OUTPUT OUT=NTOTFOR2 mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

PROC SORT DATA=NTOTFOR2; BY VEGTYPE YEAR; RUN;

title1 f=duplex h=1.0 c=black box=1 j=c 'NORTHEAST REGION BENCHMARK PROGRAM';
TITLE2 F=duplex H=1.0 c=black
 j=c   'Summary of average dry wt.(lb/ac) by forage value';
title3 F=duplex H=1.0 j=c u=1 c=black
       'for each vegetation type in the year specified';
title5 ' ';
pattern1 v=R2 c=red;
pattern2 v=l2 c=green;
pattern3 v=x2 c=blue;
pattern4 v=s c=brown;
pattern5 v=e c=black;
```

```
axis1 length=35 pct;
axis2 length=35 pct  value=none label=none ;
legend2  frame across=1 VALUE=(H=1) label=('Forage value' H=1.0);



goptions norotate cback=white ctext=black device=win TARGETDEVICE=WINPRTM
  HTEXT=0.5 FTEXT=SWISS  FBY=SIMPLEX HBY=0.6;



      PROC GCHART  DATA=NTOTFOR2
      GOUT=work.neGRAPH;
      WHERE _TYPE_ IN (1 3);
      by vegtype year;
      hBAR FORAGVAL / mean  coutline=black space=1
      TYPE=mean  SUMVAR=LB_AC legend=legend2 raxis=axis1 maxis=axis2
      subgroup=foragval DESCENDING patternid=subgroup nozeros;
      FORMAT VEGTYPE $VEGTYPE. YEAR yearbnch. FORAGVAL $QUALITY.;
      label foragval='Forage value'
            VEGTYPE='Vegetation type'
            lb_ac='Average lbs/ac'
            YEAR= 'Year';
      RUN;


/* ----------------------------------------------------------------------*/
/* PROGRAM TO PRODUCE SUMMARY GRAPHS FROM BENCHMARK CLIP DATA - THESE
   GRAPHS SUMMARIZE FORAGE AND BROWSE ACCORDING TO FORAGE TYPE        */




 PROC SUMMARY DATA=NTOTLAY MAXDEC=1 mean stderr n;
  CLASS YEAR FORM_LAY;
 VAR LTOTLB;
  OUTPUT OUT=NTOTLAY2 mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

PROC SORT DATA=NTOTLAY2; BY VEGTYPE YEAR; RUN;

title1 f=duplex h=1.0 c=black box=1 j=c 'NORTHEAST REGION BENCHMARK PROGRAM';
TITLE2 F=duplex H=1.0 c=black
 j=c   'Summary of average dry wt.(lb/ac) by forage type ';
title3 F=duplex H=1.0 j=c u=1 c=black
       'for each vegetation type in the year specified';
title5 ' ';
pattern1 v=R2 c=red;
pattern2 v=l2 c=green;
pattern3 v=x2 c=blue;
pattern4 v=s c=brown;
pattern5 v=e c=black;
axis1 length=35 pct;
axis2 length=35 pct  value=none label=none ;
legend2  frame across=1 VALUE=(H=1) label=('Forage type' H=1.0);



goptions norotate cback=white ctext=black device=win TARGETDEVICE=WINPRTM
  HTEXT=0.5 FTEXT=SWISS  FBY=SIMPLEX HBY=0.6;



      PROC GCHART  DATA=NTOTlay2
      GOUT=work.neGRAPH;
      WHERE _TYPE_ IN (1 3);
      by vegtype year;
      hBAR FORM_LAY / mean  coutline=black space=1
      TYPE=mean  SUMVAR=LB_AC legend=legend2 raxis=axis1 maxis=axis2
      subgroup=form_lay DESCENDING patternid=subgroup nozeros;
      FORMAT VEGTYPE $VEGTYPE. YEAR yearbnch. FORM_LAY $LAYCODE.;
      label form_lay='Forage type'
            VEGTYPE='Vegetation type'
            lb_ac='Average lbs/ac'
            YEAR= 'Year';
      RUN;



/* ---------------------------------------------------------------- */

/* PROCEDURE TO PRODUCE BLOCK CHARTS OF FORAGE TYPE AND QUALITY
   ORGANIZED BY YEAR FOR EACH VEGETATION TYPE */




proc sort data=nsumfor2; by year descending vegtype;
```

```
title1 f=duplex h=1.0 c=black box=1 j=c 'NORTHEAST REGION BENCHMARK PROGRAM';
TITLE2 F=duplex H=1.0 c=black
 j=c   'Summary of average dry wt.(lb/ac) by forage type and forage value';
title3 F=duplex H=1.0 j=c u=1 c=black
       'for each vegetation type in the year specified';
title5 ' ';
FOOTNOTE1 F=DUPLEX H=0.7 C=BLACK J=L
 '*  Vegetation type codes: AW/ROSE = Aspen/Rose/Forb/Reedgrass  AW/HAZEL= Aspen/Hazelnut/Sarsaparilla';
FOOTNOTE2 F=DUPLEX H=0.7 C=BLACK J=c '  AW/ROSE/BLUEBERR = Aspen/Rose/Blueberry';

pattern1 v=S c=red;
pattern2 v=X2 c=green;
pattern3 v=L1 c=blue;
pattern4 v=s c=brown;
pattern5 v=e c=black;
legend2  frame across=1 VALUE=(H=1) label=('Forage value' H=1.0);
goptions norotate cback=white ctext=black device=win TARGETDEVICE=WINPRTM

 HTEXT=0.8 FTEXT=SWISS  FBY=SIMPLEX HBY=0.8 hpos=275 vpos=80;
 /* the GOPTIONS statement defines the size of screen necessary to show the block
    chart through the hpos and vpos statements. */


      PROC GCHART  DATA=NSUMFOR2
      GOUT=TRAN1.neGRAPH;
      WHERE _TYPE_ IN (3 7);
      by year;
      block form_lay /  coutline=black
      TYPE=sum   SUMVAR=LB_AC legend=legend2 caxis=black
      group=vegtype  subgroup=foragval patternid=subgroup nozeros;
      FORMAT form_lay $laycode. foragval $quality. YEAR yearbnch.
           LB_AC 4.0;
      label form_lay='Forage type'     YEAR= 'Year'
            VEGTYPE='Vegetation type'
            lb_ac='Average lbs/ac';
      RUN;


/* Block chart of individual vegetation types showing changes by year */

      proc sort data=nsumfor2; by vegtype; run;


      PROC GCHART  DATA=NSUMFOR2
      GOUT=TRAN1.neGRAPH;
      WHERE _TYPE_ IN (3 7);
      by vegtype;
      block form_lay /  coutline=black
      TYPE=sum   SUMVAR=LB_AC legend=legend2 caxis=black
      group=year  subgroup=foragval patternid=subgroup nozeros;
      FORMAT form_lay $laycode. foragval $quality. YEAR yearbnch.
           LB_AC 4.0;
      label form_lay='Forage type'     YEAR= 'Year'
            VEGTYPE='Vegetation type'
            lb_ac='Average lbs/ac';
      RUN;

     quit;
```

## RELIABILITY ASSESSMENT ROUTINES

```
/*  NORTHEAST BENCHMARK RANGE CALCULATION PROGRAM */
 libname tran1 'c:\bench97\sasdata';
 libname library 'c:\bench97\sasdata';


/* --------------------------------------------------*/
/* CREATE DATASETS THAT PROVIDE INFO NECESSARY TO CALCULATE RANGES
   ABOUT THE MEAN    */

/* The following three steps create a subset of the dataset
     TRAN1.NEFINAL that contains information on the total dry weight
     of each of 1) the three quality classes 2) the five layers
     3)five different combinations of class data:  good quality
     grasses, good quality forbs, fair quality grasses, fair
     quality forbs, poor quality forbs (there are no poor quality
     grasses to date), good,fair, and poor quality shrubs (leaf
     biomass) and good,fair and poor quality shrubs (twig
     biomass).  This step reads in the dataset created in the
     previous step, adds all of the various dry weight measures
     together for each layer (forb or grass) for each category of
     quality, and outputs observations to various datasets.  */


PROC SORT DATA=TRAN1.NEFINAL; BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY;
RUN;


DATA NSUMFOR;  /*subset of data where totals for each layer belonging */
              /*to a particular vegetation type in a given year      */
              /*are calculated for each plot in the type             */

DO I=1 TO NUMOBS;
 SET TRAN1.NEFINAL(KEEP=PLOTNO FORAGVAL lb_ac kg_ha biomass FORM_LAY YEAR
             VEGTYPE) NOBS=NUMOBS;
/* NOBS option defines # of DO loop iterations */
  BY VEGTYPE YEAR PLOTNO FORAGVAL FORM_LAY ;
 TOTLB+LB_AC;
 TOTKG+KG_HA;
 TOTGM+BIOMASS;
   IF LAST.form_lay THEN DO; OUTPUT;
     TOTLB=0.0;   /* Reset variables to 0 for next iteration */
     TOTKG=0.0;
     TOTGM=0.0;
    END;
 END;

LABEL TOTGM='Total wt(gm)' TOTKG='Total wt(kg/ha)'
      TOTLB='Total wt(lb/ac)';
RUN;

PROC SORT DATA=TRAN1.NEFINAL OUT=NSUMFORQ; BY  vegtype year PLOTNO FORAGVAL;
PROC SORT DATA=TRAN1.NEFINAL OUT=NSUMFORL; BY  vegtype year PLOTNO FORM_LAY;


 /*Step creates dataset with totals by forage quality only */
DATA NTOTFOR (keep=gtotlb gtotkg gtotgm year
             lb_ac kg_ha foragval biomass plotno vegtype species);
DO I=1 TO NUMOBS;
 SET NSUMFORQ NOBS=NUMOBS; /* NOBS option defines # of DO loop iterations */
  BY vegtype year PLOTNO FORAGVAL ;
 GTOTLB+LB_AC;
 GTOTKG+KG_HA;
 GTOTGM+BIOMASS;
   IF LAST.foragval     THEN DO; OUTPUT;
     GTOTLB=0.0;   /* Reset variables to 0 for next iteration */
     GTOTKG=0.0;
     GTOTGM=0.0;
    END;
 END;

LABEL GTOTGM='Total wt(gm)'         GTOTKG='Total wt(kg/ha)'
      GTOTLB='Total wt(lb/ac)';
RUN;

 /* Step creates dataset with totals by layer for each plot within
    a vegetation type during a given year                          */

 DATA NTOTLAY (keep= ltotlb ltotkg ltotgm year
                    lb_ac kg_ha form_lay biomass plotno vegtype species);
 DO I=1 TO NUMOBS;
  SET NSUMFORL NOBS=NUMOBS; /* NOBS option defines # of DO loop iterations */
   BY vegtype year PLOTNO FORM_LAY;
  LTOTLB+LB_AC;
  LTOTKG+KG_HA;
  LTOTGM+HERBWT;
    IF LAST.form_lay THEN DO; OUTPUT;
```

```
      LTOTLB=0.0;   /* Reset variables to 0 for next iteration */
      LTOTKG=0.0;
      LTOTGM=0.0;
     END;
  END;

 LABEL LTOTGM='Total wt(gm)'          LTOTKG='Total wt(kg/ha)'
       LTOTLB='Total wt(lb/ac)';
 RUN;

/*----------------------------------------------------------------- */
  /* SUMMARIZE DATA USING PROC SUMMARY TO GET _TYPE_ VARIABLES */

/* SUMMARY OF FORAGE TYPE AND FORAGE VALUE INFO */

 PROC SUMMARY DATA=NSUMFOR MAXDEC=1 mean stderr n;
  CLASS YEAR FORM_LAY foragval;
 VAR TOTLB;
  OUTPUT OUT=NSUMFOR2 mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

PROC SORT DATA=NSUMFOR2; BY VEGTYPE YEAR; RUN;

/* SUMMARY OF FORAGE VALUE INFO */

 PROC SUMMARY DATA=NTOTFOR MAXDEC=1 mean stderr n;
  CLASS YEAR foragval;
 VAR GTOTLB;
  OUTPUT OUT=NTOTFOR2 mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

PROC SORT DATA=NTOTFOR2; BY VEGTYPE YEAR; RUN;

/* SUMMARY OF FORAGE TYPE INFO */

 PROC SUMMARY DATA=NTOTLAY MAXDEC=1 mean stderr n;
  CLASS YEAR FORM_LAY;
 VAR LTOTLB;
  OUTPUT OUT=NTOTLAY2 mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

PROC SORT DATA=NTOTLAY2; BY VEGTYPE YEAR; RUN;

/* SUMMARY OF SPECIES INFO FOR SPECIES WITH >5.0 LB/AC ON AVERAGE */

 PROC SUMMARY DATA=TRAN1.NEFINAL MAXDEC=1 mean stderr n;
  WHERE NOT(TRANSECT=:'T' AND FORM_LAY='B');
  /* the WHERE statement gets rid of observations in the master
     dataset that cause averages to be wrongly computed (i.e.
     all of the weights are zero for shrubs that were noted as
     to cover in the microplots on the forb/grass transects */
  CLASS YEAR FORM_LAY foragval SPECIES;
 VAR LB_AC;
  OUTPUT OUT=SUMMARY mean=LB_AC stderr=stderr n=n;
BY VEGTYPE; RUN;

PROC SORT; BY VEGTYPE FORM_LAY descending LB_AC;
RUN;

/* ------------------------------------------------------------- */
 /* DATA STEPS TO CALCULATE RANGE AT TWO CONFIDENCE LEVELS */
 /* USING _TYPE_ AND OTHER VARIABLES FROM PROC SUMMARY */

data TYPVAL;
retain p95 0.05 p80 0.20;
array p p80 p95;
set NSUMFOR2 (where=((_type_=3) AND LB_AC>2.0) RENAME=(FORAGVAL=FV FORM_LAY=FL));
do i=1 to 2;                   /*formula from p 22 of SAS Procedures manual */
 df=n-1;
 b=betainv(p{i},df/2,.5);
 f=df*(1-b)/b;
 t=sqrt(f);
 lower=lb_ac - t*stderr;
 upper=lb_ac + t*stderr;
 diff=t*stderr;
 errorpct=(diff/lb_ac)*100;
 confid=(1-p{i})*100;
 drop f t b df i p80 p95 ;
 range=put(lb_ac,5.1)||' +/- '||put(diff,5.1);
 FORAGVAL=PUT(FV,$QUALITY.);  FORM_LAY=PUT(FL,$LAYCODE.);
output;

END;
RUN;

PROC SORT DATA=TYPVAL; BY CONFID VEGTYPE FORM_LAY FORAGVAL ;
RUN;
```

```
data LAYER;
retain p95 0.05 p80 0.20;
array p p80 p95;
set NTOTLAY2 (where=((_type_=1) AND LB_AC>2.0) RENAME=(FORM_LAY=FL));
do i=1 to 2;                    /*formula from p 22 of SAS Procedures manual */
 df=n-1;
 b=betainv(p{i},df/2,.5);
 f=df*(1-b)/b;
 t=sqrt(f);
 lower=lb_ac - t*stderr;
 upper=lb_ac + t*stderr;
 diff=t*stderr;
 errorpct=(diff/lb_ac)*100;
 confid=(1-p{i})*100;
 drop f t b df i p80 p95 ;
 range=put(lb_ac,5.1)||' +/- '||put(diff,5.1);
 FORM_LAY=PUT(FL,$LAYCODE.);
output;

END;
RUN;

PROC SORT DATA=LAYER; BY CONFID VEGTYPE DESCENDING LB_AC;
RUN;

data VALUE;
retain p95 0.05 p80 0.20;
array p p80 p95;
set NTOTFOR2 (where=((_type_=1) AND LB_AC>2.0) RENAME=(FORAGVAL=FV));
do i=1 to 2;                    /*formula from p 22 of SAS Procedures manual */
 df=n-1;
 b=betainv(p{i},df/2,.5);
 f=df*(1-b)/b;
 t=sqrt(f);
 lower=lb_ac - t*stderr;
 upper=lb_ac + t*stderr;
 diff=t*stderr;
 errorpct=(diff/lb_ac)*100;
 confid=(1-p{i})*100;
 drop f t b df i p80 p95 ;
 range=put(lb_ac,5.1)||' +/- '||put(diff,5.1);
 FORAGVAL=PUT(FV,$QUALITY.);
output;

END;
RUN;

PROC SORT DATA=VALUE; BY CONFID VEGTYPE DESCENDING LB_AC;
RUN;

data SPECIES;
retain p95 0.05 p80 0.20;
array p p80 p95;
set summary (where=((_type_=5) AND LB_AC>5.0));
do i=1 to 2;                    /*formula from p 22 of SAS Procedures manual */
 df=n-1;
 b=betainv(p{i},df/2,.5);
 f=df*(1-b)/b;
 t=sqrt(f);
 lower=lb_ac - t*stderr;
 upper=lb_ac + t*stderr;
 diff=t*stderr;
 errorpct=(diff/lb_ac)*100;
 confid=(1-p{i})*100;
 drop f t b df i p80 p95 ;
 range=put(lb_ac,5.1)||' +/- '||put(diff,5.1);
output;

END;
RUN;

PROC SORT DATA=species; by confid vegtype form_lay DESCENDING LB_AC;
run;

/* -------------------------------------------------------------- */
 /* PRINT PROCEDURES TO GENERATE OUTPUT FROM DATA STEPS */

options nodate pageno=1 pagesize=60 linesize=78;
PROC PRINTTO NEW PRINT='C:\BENCH97\SASOUT\neRNG97.TXT';
PROC PRINT DATA=TYPVAL noobs  split='*';
by confid vegtype;
title 'MEAN AND RANGE OF BIOMASS (LB/AC) FOR TYPE AND VALUE OF FORAGE';
TITLE2 'FOR NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS';
TITLE3 ' ';
LABEL VEGTYPE='Vegetation type'  Form_lay= 'Forage type'
      foragval='Forage value' lb_ac='Average lbs/ac'
      upper='Upper limit '
      lower='Lower limit '
```

```
      confid='Confidence*level(%)'
      range='Range for con-*fidence level'
      n='#plots'
      errorpct='% error';
VAR FORM_LAY FORAGVAL RANGE errorpct CONFID;
format form_lay $laycode. foragval $quality. lower upper lb_ac 6.1
    errorpct 3.0 confid 3.0 n 3.0 range $char15.;
run;
titles; options;

PROC PRINT DATA=LAYER noobs  split='*';
by confid vegtype ;
title 'MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES';
TITLE2 'NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS';
TITLE3 ' ';
LABEL VEGTYPE='Vegetation type'  Form_lay= 'Forage type'
      lb_ac='Average lbs/ac'
      upper='Upper limit '
      lower='Lower limit '
      confid='Confidence*level(%)'
      range='Range for con-*fidence level'
      n='#plots'
      errorpct='% error';
VAR FORM_LAY range errorpct confid ;
format form_lay $laycode. lower upper lb_ac 6.1
    errorpct 3.0 confid 3.0 n 3.0 range $char15.;
run;
titles; options;


PROC PRINT DATA=VALUE noobs  split='*';
by confid vegtype ;
title 'MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE VALUE CLASSES';
TITLE2 'NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS';
TITLE3 ' ';
LABEL VEGTYPE='Vegetation type'
      foragval='Forage value' lb_ac='Average lbs/ac'
      upper='Upper limit '
      lower='Lower limit '
      confid='Confidence*level(%)'
      range='Range for con-*fidence level'
      errorpct='% error'
      n='#plots';
VAR FORAGVAL range errorpct confid;
format foragval $quality. lower upper lb_ac 6.1
    errorpct 3.0 confid 3.0 n 3.0 range $char15.;
run;
titles; options;

PROC PRINT DATA=SPECIES noobs  split='*';
by confid vegtype FORM_LAY ;
title 'MEAN AND RANGE OF BIOMASS (LB/AC) FOR FORAGE TYPES';
TITLE2 'NORTHEAST REGION BENCHMARK VEGETATION TYPES- ALL YEARS';
TITLE3 ' ';
LABEL VEGTYPE='Vegetation type'  Form_lay= 'Forage type'
      foragval='Forage value' lb_ac='Average lbs/ac'
      upper='Upper limit '
      lower='Lower limit '
      confid='Confidence*level(%)'
      SPECIES='Species code'
      range='Range for con-*fidence level'
      n='#plots'
      errorpct='% error';
VAR SPECIES range errorpct confid ;
format form_lay $laycode. foragval $quality. lower upper lb_ac 6.1
      errorpct 3.0 confid 3.0 n 3.0 range $char15.;
run;
titles; options;
proc printto; run;
```

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